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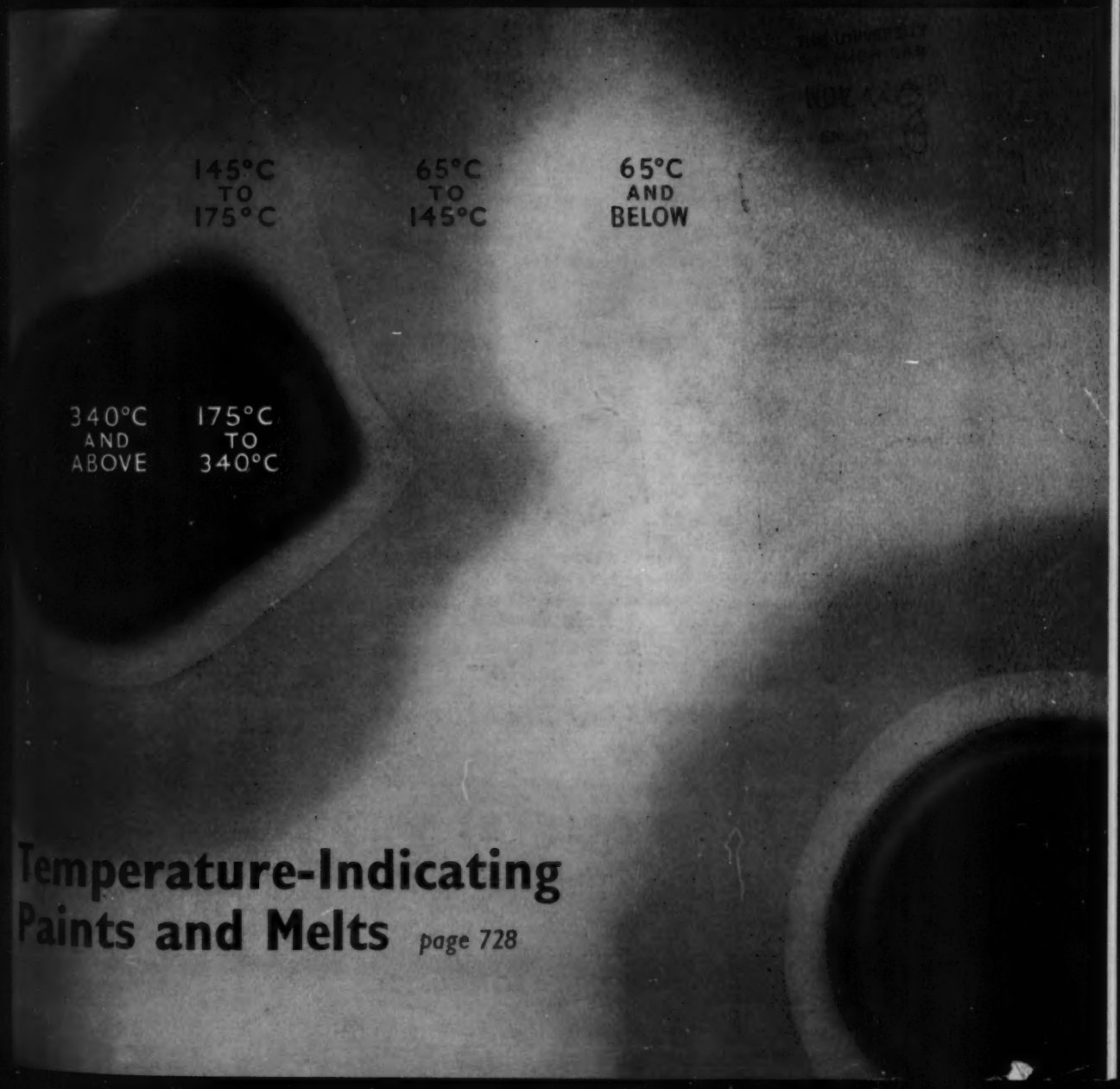

Temperature-Indicating Paints and Melts page 728

RELAYABILITY

The special quality of Magnetic Devices Relays which embraces

✳ **RELIABLE OPERATION AND PERFORMANCE** ✳ **ACCURATE RESPONSE**

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Magnetic Devices manufacture a complete range of relays for every application in the electrical and electronic industries. Robust construction, proven reliability, versatility of contact arrangements—simple to re-arrange to customers' requirements.

The standard range includes enclosed, hermetically sealed, miniature, sub-miniature, plug-in, screw terminal and transistorised types; for A.C. or D.C. operation.

Special relays for prototype equipment can be supplied—consult our design engineers.

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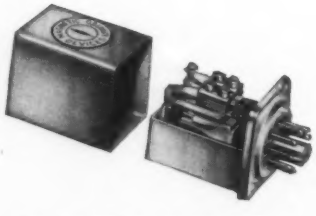
Series 336 Relay. A new plug-in, sub-miniature sealed relay with double-changeover contacts capable of switching a 2-amp. resistive load at 28 v D.C., or 110 v A.C. Operates on 0.35 watt in 3 ms., releases in 2 ms.



Series 596 HS Relay (Transistorised). Hermetically sealed relay for control by ultra-sensitive contacts. For handling the loads of circuits such as heavy-duty contactors; solenoids, heaters, etc. Controlled by very light inputs.

Series 592/597 Relay. A new miniature relay specifically designed for use with printed circuits.
All contact and coil connection spills coincide with the recommended standard of 0.1 inch grid. Can accomodate up to 4 changeover contacts in D.C. version or 3 in A.C. version. Single or double wound coil available.

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Engineering Materials and Design

★ *The Magazine for Engineering Designers*

A HEYWOOD PUBLICATION

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Showing how heat gradients are clearly indicated in colour on a panel coated with temperature-indicating paint (Headland Engineering Developments Ltd.)

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ISSUE AT A GLANCE

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TEMPERATURE-INDICATING PAINTS AND MELTS **728**

Dealing mainly with methods of use, application procedure, readability, and assessment of errors.

By **Dr. J. Miller**

SELECTING SPRING FASTENERS **734**

Two-part article written by members of two companies producing spring-type fasteners.

By **R. H. Exton and G. Marden**

MATERIALS SELECTION IN DESIGN **744**

Suggesting new methods of presentation for data on the properties of engineering materials.

By **J. S. Shapiro**

DESIGN WITH CAST COPPER-BASE ALLOYS **752**

Describing some of the interesting developments which have recently taken place in the bronze and brass founding industry.

By **G. Swinyard**

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Résumés

SELECTION DE FERMOIRS A RESSORT

R. H. Exton et G. Marden *page* 734

Un article en deux parties écrit par des membres de deux importantes compagnies produisant des fermoirs à ressort. Il est destiné aux ingénieurs et offre des indications sur les applications possibles de ces systèmes.

PEINTURES ET PRODUITS FONDUS INDICATEURS DE TEMPERATURE

Dr. J. Miller *page* 728

L'auteur examine diverses méthodes pour utiliser ce genre d'indicateur de température, puis étudie de manière critique les procédures d'application, les interprétations et l'établissement des marges d'erreur. Il conclue avec des tables donnant les indicateurs que l'on peut obtenir dans le Royaume-Uni.

SELECTION DES METAUX DANS LA CONSTRUCTION

J. S. Shapiro page 744

Dans cet article, l'auteur propose de nouvelles méthodes de présentation des données relatives aux propriétés des matériaux de construction mécanique.

EMPLOI DES PIECES MOULEES EN ALLIAGE DE CUIVRE

G. Swinyard page 752

L'auteur décrit quelques-uns des progrès intéressants qui ont été réalisés dernièrement dans le domaine de la fonderie employant le bronze et le laiton. Il appuie particulièrement sur les points suivants: recherches sur les bronzes industriels; nouveaux alliages pour pièces coulées résistant à la pression; bronzes pour paliers; nouvelles méthodes de coulage; et contrôle du traitement et de la fusion des métaux.

Kurzreferate

AUSWAHL VON SCHNAPPVERSCHLÜSSEN

R. H. Exton und G. Marden *Seite* 734

Dieser zweiteilige Artikel wurde von Mitgliedern zweier führender Erzeuger von Schnappverschlüssen verfasst. Er richtet sich an den Konstrukteur und hat den Zweck, ein besseres Verständnis für die verschiedenen Anwendungen dieser Einheiten zu vermitteln.

TEMPERATURANZEIGENDE SCHMELZEN UND LACKE

Dr. J. Miller *Seite* 728

Der Verfasser bespricht verschiedene Mittel und Wege zur Verwendung dieser Art von Temperaturanzeigern und erklärt das Anwendungsverfahren, die Ablesung und die Fehlerbestimmung. Der Schluss des Artikels bringt Tabellen über die in Grossbritannien verfügbaren Anzeigeeinheiten.

BAUSTOFFWAHL ZU KONSTRUKTIONSZWECKEN

J. S. Shapiro *Seite* 744

Der Verfasser schlägt neue Methoden der Datendarstellung der Eigenschaften von Baustoffen vor.

KONSTRUKTIONEN MIT KUPFERLEGIERUNGSGUSSSTUCKEN

G. Swinyard *Seite* 752

Der Verfasser beschreibt einige der interessanten, jüngeren Entwicklungen im Bronze- und Messingguss. Besondere Aufmerksamkeit wird den Bronzen, neuen Legierungen für druckdichte Gussstücke, Lagerbronzen, neuen Gussmethoden und der Regelung und Behandlung, sowie dem Schmelzen von Metallen gewidmet.

Резюме

ВЫБОР ПРУЖИННЫХ ЗАЖИМОВ

Р. Г. Экстон и Дж. Марден Стр 734

Первая часть статьи, написанной членами двух ведущих компаний, которые занимаются производством зажимов пружинного типа. Статья рассчитана на конструкторов и имеет целью дать им лучшее понимание различных возможностей и форм применения этих деталей.

ПЛАВКИ И КРАСКИ В КАЧЕСТВЕ УКАЗАТЕЛЕЙ ТЕМПЕРАТУРЫ

Д-р Дж. Миллер Стр. 728

Автор обсуждает различные способы использования указателей температуры этого типа и останавливается на процедуре применения, ясности показаний и учете ошибочности. В заключение он приводит таблицы, перечисляющие индикаторы этого типа, которые находятся в продаже в Великобритании.

ВЫБОР КОНСТРУКТОРСКИХ МАТЕРИАЛОВ

Дж. Шапиро Стр. 744

Автор предлагает новые методы освещения данных, касающихся свойств материалов, применяемых в машиностроении.

КОНСТРУИРОВАНИЕ С ОТЛИВКАМИ ИЗ МЕДНЫХ СПЛАВОВ

Дж. Свинярд Стр. 752

Автор описывает некоторые интересные достижения, произведенные в последнее время в области литья бронзы и латуни. Особое внимание уделяется пушечной бронзе; новым отливкам, сохраняющим герметичность под давлением; бронзе для подшипников; новым литейным методам; а также управлению процессами металлургической обработки и плавки.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Engineering Materials and Design Association

READERS WHO ARE MEMBERS of the *E. M. & D.* Association are invited to assemble and meet their business colleagues at Stand H6 at the *E. M. & D.* Exhibition, Earls Court, November 13 to 18, where telephone facilities and details of the Association will be available. Members are reminded that applications to attend the dinner at the Cafe Royal should be sent to the Honorary Secretary as soon as possible. The editorial staff of *E. M. & D.* will be available during the week of the Conference and Exhibition on Stands D6 and H6.

Tungsten Carbide Development

THE PRODUCTION OF a fine-grain tungsten carbide cutting tip has enabled the various heat-resisting alloys to be satisfactorily machined more easily and quickly. Fineness of grain is not in itself the answer, but a combination of this with precision sintering and correct proportioning of alloys has enabled Hoy Carbides Ltd., to produce the CW grade, which has given impressive performance figures over several months with leading British aircraft and missile manufacturers. Experience has shown that this grade will machine the more difficult cutting alloys at greater speed, giving a better finish and more components per regrind than any carbide previously available.

Owing to the difficulty of obtaining consistent-quality tungsten powder of extreme fineness of grain within the bounds of reasonable cost, it was decided to use raw materials normally available, and to process these in a specially-designed plant which includes high-vacuum furnaces with precision control.

Electronic Defrosting

AN ENTIRELY NEW electronic defrosting installation has been designed and built by the Process Heating Division of Pye Ltd., and installed at the Grimsby fish factory of the Ross trawler-fishing and frozen food group.

With this new equipment, slabs of deep-frozen fish at a temperature of down to −34 deg. C. pass on a conveyor belt through a tunnel-oven which contains a radio-frequency field. This field causes molecular agitation in the fish, melting it right through so quickly that, for example, a ton can be brought from its cold storage temperature to melting point in 1 hr. Deep-frozen fish, which until now has had to be thawed by warm air, warm water, or other means for at least 24 hr. and in some cases several days, can now be unfrozen ready for use in about 15 min. In this technique, the fish or other material to be thawed is placed between two plates or electrodes, to which powerful radio-frequency energy is applied, and is heated by the intense alternating electric field between the plates; the fish acts like the dielectric in a condenser.

The most outstanding feature of dielectric heating is that every part of the product is heated uniformly throughout its depth, so that the temperature increases uniformly in every part of the whole slab. There is no danger of overheating the outside while leaving the core of the slab frozen. By varying the energy fed into the system, or the time the product spends between the electrodes, the final temperature can be accurately controlled. The operation is extremely consistent, and processing cost is low.

The new plant is built on the modular or unit system and consists of three tunnel ovens in series, each powered by a 12 kW. industrial r.f. generator energising a balanced pair of electrode plates situated in each oven. The frozen fish slabs pass through the ovens on a continuous conveyor belt 32 in. wide beneath a balanced pair of electrodes. Conveyor speed can be varied. The belt is continuously cleaned by a nylon brush and water jets. As a result of the modular principle adopted, greater throughputs can be obtained simply by adding further generator-oven units and by increasing the belt speed accordingly.

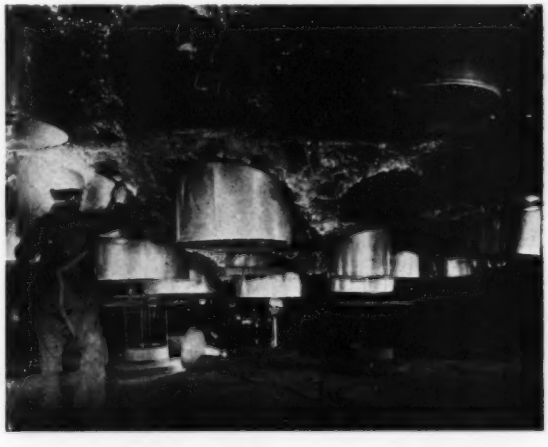
Each generator employs the latest type of water-cooled industrial power triode valve in a Colpitts circuit, and operates on the internationally assigned I.S.M. band of 27.12 Mc/s.

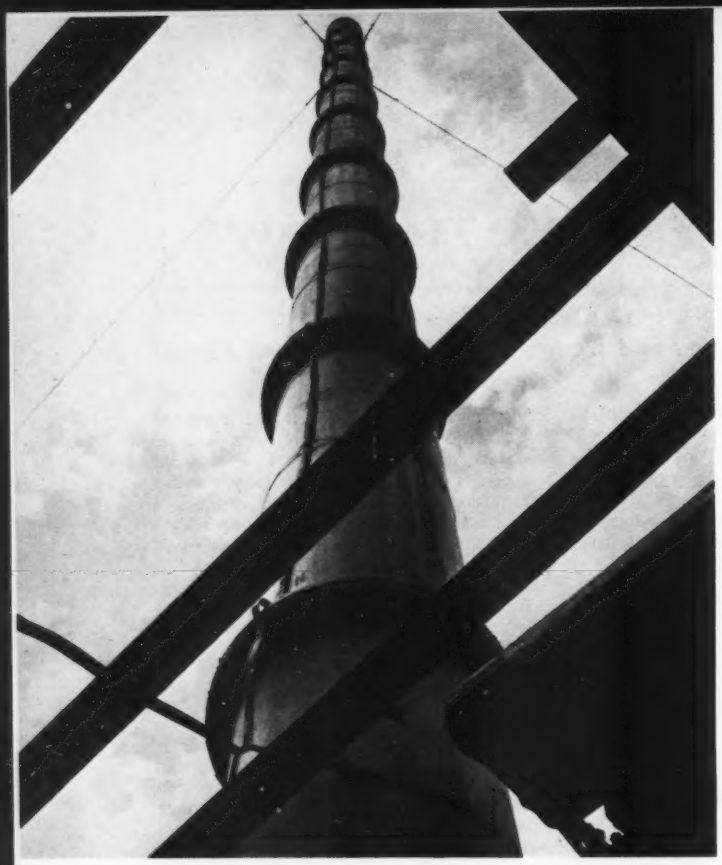
Reactor Pressure Vessel Successfully Heat-treated

A 70-FT. DIA. reactor pressure vessel, weighing 1,800 tons, has recently been stress-relieved on site at Hunterston Nuclear Generating Station, Ayrshire, Scotland. Situated at a mean height of 85 ft. above ground level, the vessel was heated to a temperature of 550 deg. C., soaked for 12 hr., and then allowed to cool slowly. During the process a high degree of control was essential to prevent the temperature difference between any two points in the vessel exceeding a certain specified maximum.

The pressure vessel and included components were heated by a series of freely radiating Brightray strips supported by wire links and ceramic insulators. Some strips were mounted circumferentially between the spherical pressure vessel and the cylindrical inner heat shield, while others on the top and bottom crowns followed approximately the curvature of the vessel. With the system of heater suspension employed, a curtain-like structure of heater elements was built up in the space between the inner heat shield and the pressure vessel. Temperatures were measured at some 400 points by means of chrome-alumel thermocouples.

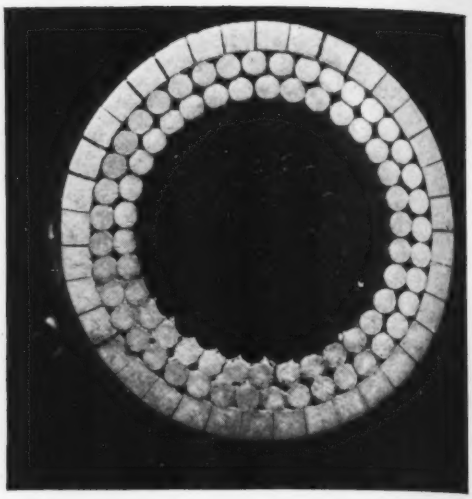
All external surfaces of the pressure vessel, ducts and nozzles were insulated to reduce heat losses—in most cases this insulation consisted of layers of Rocksil and aluminium foil. The accompanying illustration shows Rocksil thermal insulation applied to the bottom crown of the reactor pressure vessel. The charge nozzles were insulated individually and then covered by a thin aluminium container, as shown.





TO STAND FOR EVER

No painting or maintenance will be required for this 150-ft. stack, which forms part of the F. W. Berk & Co. Ltd. acid plant. The chimney has been coated with British Geon Ltd. p.v.c. by Plastics Coatings Ltd.

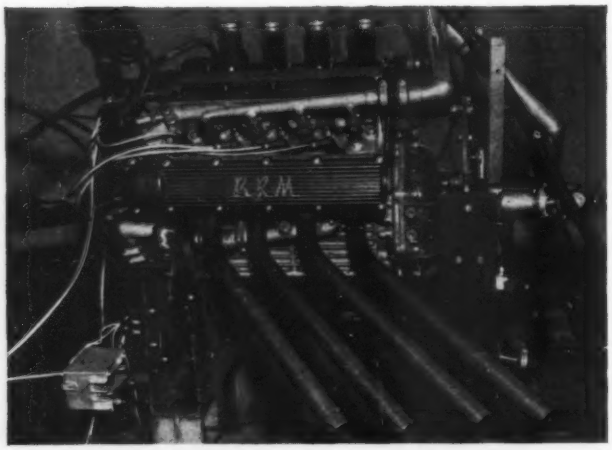


TIGHTLY PACKED

Cross-section of an aluminium conductor made by Alcan Industries Ltd. for the new power-lines crossing the Thames at West Thurrock.

PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN



LIGHT-ALLOY RACING ENGINE

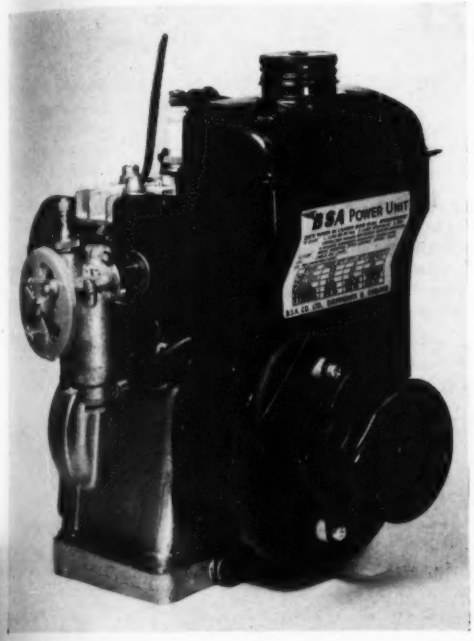
The new B.R.M. V-8 1½-litre racing engine is shown above during bench testing. This engine is constructed entirely of light alloy, and uses Lucas direct-port fuel injection and transistorized ignition system. (Photograph by George E. Phillips, of *Autosport*.)

LIGHTWEIGHT DRAINS

The Corlix spiral corrugated drainage pipe, available for the first time in aluminium, is claimed by the manufacturers (Kaiser Aluminium and Chemical Corp.) to be competitive with conventional drainage pipes.

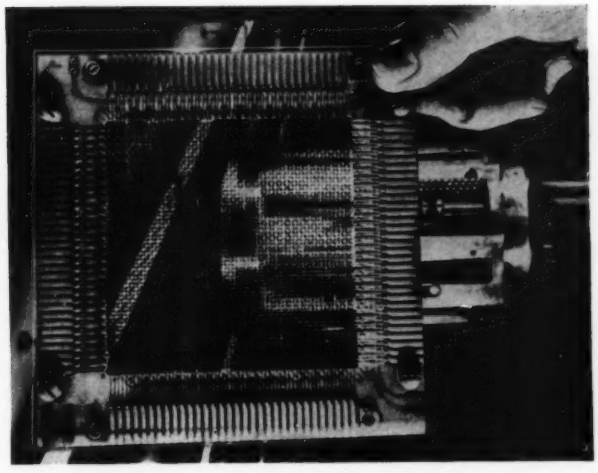
MOTOR PROTECTION

Typical example of a General Electric Co. (U.S.A.) type-CR124H winding protector installed in an electric motor.



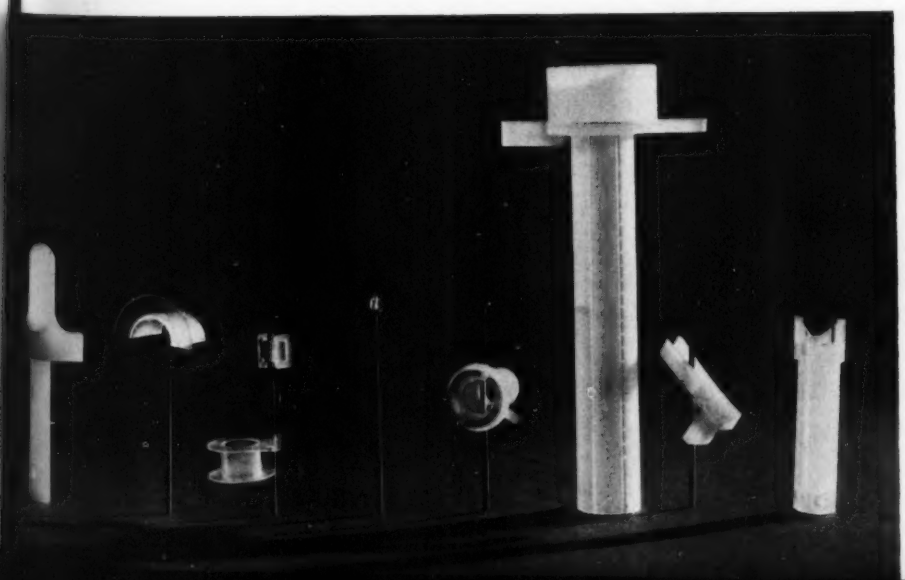
DIE-CAST ALUMINIUM-ALLOY PETROL ENGINE

The new B.S.A. 50-cc. four-stroke engine shown on the left weighs only 14 lb. With a cast-in iron cylinder-liner and valve seats, the engine is designed for reliability and good low-speed torque.



MEMORY FRAME

Core memory frame for the new Remington Rand Univac solid state computor. The complete system has a memory of 110,880 digits.



MIGHTY MINIATURES

Miniature plastics parts in Du Pont Delrin acetal and Zytel nylon resins, shown in relation to ordinary household pins.

E.M.D. 7945 for further information

TECALEMIT *Nylon* TUBING ACHIEVES **WORLD** SUPREMACY

Tecalemit, pioneers of extruded nylon tubing, owe their present supremacy in this sphere to the most exacting research, testing and development in co-operation with the producers of the raw material. Tecalemit have now achieved marvellous limits of precision in extruded nylon tubing—limits unequalled and indeed unthought of previously—an exclusive technical triumph.

Flexible and rigid Tecalemit nylon tubing now outperforms metal, other plastics and rubber for industrial and automotive oil and fuel lines. Tecalemit Tubing is fitted as standard by such great names as Aston-Martin, Austin, Ford, International Harvester, Jaguar, Massey-Ferguson, Rover and many large industrial users including, of course, Tecalemit industrial lubrication installations.

Tubes of precise inside diameter of ¼" and less have proved under test to be unharmed by

1,100 vibrations per minute at 250°F and 45 p.s.i. for 700 hours

immersion in Derv at 212°F for 200 hours

air temperatures of −78°C

tensile strains of 100 lb (after being dry-air aged at 212°F)

And they save up to 50% in initial cost!

Tecalemit Nylon Tubing almost halves fitting times; is free of internal abrasive scale; resists shock, even below -70°C; resists most solvents, corrosion and fungal attack; is unaffected even by strong ultra-violet light, and form-stable over a wide temperature range.

For full particulars write to:

TECALEMIT (ENGINEERING) LTD.

(SALES EMD) PLYMOUTH · DEVON

NEW! TECALEMIT HIGH PRESSURE NYLON HOSE

Following in the great tradition of Nylon Tubing, Tecalemit present a new High Pressure Nylon Hose. More durable, flexible, lighter, stronger and more stable than any other hose on the market. And highly competitive in price! Ask for details when enquiring about Tecalemit Nylon Tubing.

Fibre-metal Mats

USING POROUS FIBRE-METAL MATS, metallurgists at Armour Research Foundation, U.S.A., have developed a new brazing process which enables large gaps to be bridged. The fibre-metal mats are prepared by suspending short lengths of metal fibres in glycerine, then felting them to produce a porous body which can be pressed, rolled and sintered. The mats are infused with lower-melting brazing filler metal and placed in the joint to be brazed, which is then heated above the melting point of the filler alloy.

This new process, developed on a project for the Association of American Railroads, is called fibre-metal shim brazing. Production of the fibre-metal mats is based on the Foundation's development of fibre metallurgy, a technique in which thin fibres of metal are interlocked like a felt cloth and bonded together with heat.

In addition to bridging large gaps, the process offers the following advantages: wide variation in composition and properties, since both the fibre-metal mat and the impregnating material can be controlled; greater mismatching of surfaces can be tolerated; filler metal viscosity can be increased where excessive fluidity causes difficulty; and greater strength of thick joints, because of the reinforcement provided by the fibrous network inherent in the mats.

The Aquascan

THE NECESSITY for ensuring the cleanliness of aircraft fuel has become increasingly important, and provides a major challenge for equipment which measures on a continuous basis the undissolved water content of fuels.

Thermal Control Co. Ltd., are now producing the Aquascan, an instrument designed as a light absorption comparator in which two beams of light, from a single source, are compared photo-electrically after each has passed through associated liquid-filled absorption cells. One absorption cell contains turbine fuel as sampled from the fuel delivery stream, and the other contains a sample of the same fuel at an elevated temperature, the sampling being done on a continuous basis. When undissolved water is present in the stream from which the samples are drawn, the fuel entering one of the absorption cells is cloudy, whereas the fuel entering the other cell is clear, since the water is in solution at the elevated temperature. A condition is therefore achieved which allows for the optical comparison of the turbine fuel containing water droplets with a clear sample of the same fuel, and a measure of the light absorption due to the undissolved water can be made.

For such measurements to be established on a quantitative basis, however, it is necessary to ensure that the water droplets in the feed to the instrument have a consistent particle size distribution; tests have shown that the particle size distribution is sensitive to pump speed. Of necessity, therefore, the fuel feed to the instrument is passed through a disperser which modifies the size of the water droplets to meet requirements.

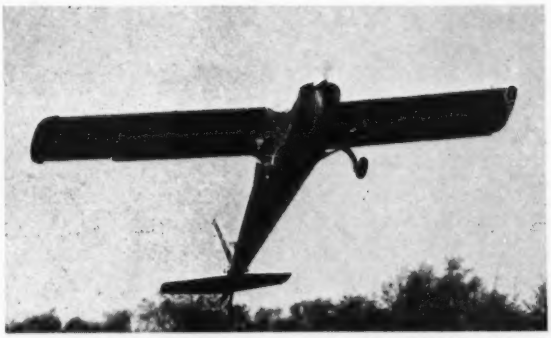
With an optical system of this type it is apparent that entrained air would also cause light absorption, in a similar manner to the water droplets, and so give rise to erroneous water indications. Air separators are therefore included in the sample fuel system.

No skilled operators or observers are required to obtain accurate water determinations, and the contamination level alarm can be set to meet prevailing requirements. The results are unambiguous, and do not depend on personal judgment. The instrument has the necessary sensitivity for the detection of very low concentrations of undissolved water, and is therefore very suitable for assessing the performance of water separator equipment on static test-rigs.

Reinforced Plastics Undercarriage

A NEW short take-off and landing (S.T.O.L.) aircraft, MFI-10 Vipan, designed and manufactured by Ab Malbo Flygindustri, of Sweden, incorporates for the first time in aviation a glass-fibre reinforced plastics undercarriage.

The MFI-10 experimental aircraft was developed to investigate new materials and design methods, and to find out if the existing gap in the present range of light aircraft could be filled with a S.T.O.L. aircraft coming between the ordinary



light aircraft and the present very expensive S.T.O.L. aircraft category. Although the aircraft is still in an early phase of its flight test programme, the preliminary targets have already been achieved.

An aircraft undercarriage is always one of the most heavily stressed parts, and this is particularly so on S.T.O.L. aircraft, which are often used on very rough and unprepared landing grounds. In addition to the strength, weight and economic requirements, an undercarriage must also have good shock-absorbing and damping effect. From the behaviour of a reinforced plastics spring it was theoretically assumed that a glass-fibre reinforced plastics undercarriage would have a good damping effect provided that the design was correct. For that reason a number of design studies were made, and correlation tests performed in the laboratory.

The attaching of the undercarriage to the fuselage forms a particularly difficult design problem, as the normal design procedure cannot be used with advantage when fastening a glass-fibre reinforced plastics part to the load-carrying members of the fuselage.

New development work is under way to further reduce weight and costs, so as to make this undercarriage even more attractive to aircraft designers.

Problems with Fuel Cells

AT THE RECENT annual meeting of the British Association for the Advancement of Science, a paper given by a member of the Shell Thornton Research Centre outlined the probable trends of the fuel cell, which converts the chemical energy of a fuel directly into electricity, and is in principle a most attractive device, as it is potentially capable of working at overall thermal efficiences of 70 to 80%. The fuel cell can already compete with conventional engines in certain military applications, where cost is not of primary importance and the silence of operation is.

The hydrogen and oxygen fuel cell is at the present time both the simplest and the most highly developed of the available fuel cells, the energy released by the formation of water from hydrogen and oxygen being available as electric power. However, hydrogen is an inconvenient fuel, and the disposal of the water is also a problem.

An alternative type of fuel cell is the high-temperature unit, using fused lithium and potassium carbonates as the electrolyte. This cell operates at a temperature of about 600 or 700 deg. C., and uses a mixture of air and carbon dioxide on one electrode. The other electrode is supplied with a fuel which can be a hydrocarbon or, for example, a mixture of hydrogen and carbon monoxide. This cell, too, presents a number of engineering problems, including the need for corrosion-resistant materials to withstand the corrosive electrolyte. Starting also presents a problem, as the electrolyte does not conduct at a temperature below 500 deg. C.

One low-temperature fuel cell is that employing a liquid fuel such as methanol. At present such cells are bulky and not very efficient, and have problems which are as yet unsolved.

Looking to the future, it may well be attractive to synthesise hydrazine from atmospheric nitrogen and water. This fuel is ideal for fuel cells, and it may then be possible to make a hydrazine-air fuel-cell which, combined with a lightweight electric motor, would compete very successfully with the gasoline engine of today.

Which craft,

OA/5956

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Cryogenic Bearings

AS THE TEMPERATURE of a number of materials, lead for example, is lowered the electrical resistivity drops steadily, apparently toward zero resistance at zero absolute temperature. The temperature at which the resistance drops to zero is called the critical temperature, and the phenomenon of zero resistance, superconductivity.

If a superconducting material at some point below its transition temperature is subjected to an increasing magnetic field, at a field intensity known as the critical transition field, it will become conductive again. This critical transition field is a function of temperature, and varies in an approximately parabolic fashion from zero at the transition temperature to a maximum at absolute zero. The magnetic field may be either an external field, or the field caused by currents being carried within the superconductor. Niobium has one of the highest transition temperatures and one of the highest critical fields at lower temperatures, and for this reason, and because it can be obtained fairly easily in the pure form, it is being used in many experimental devices. In addition to the pure metallic elements, some intermetallic compounds also show the phenomenon of superconductivity.

The counter currents, or eddy currents, generated in a metal surface exposed to a changing magnetic field persist in a superconductor, and thus prevent penetration of the superconductor by the magnetic field. Thus a superconductor is "diamagnetic", and acts as a magnetic insulator. When a material is caused to become superconductive in the presence of a magnetic field, the field is found to be expelled from the superconductor (the Meissner effect). Unfortunately, in most cases the degree of expulsion is not perfect, and some magnetic field is usually trapped within the superconductor. For this reason sensitive and accurate devices cannot be made relying upon the Meissner effect to exclude the field.

The ability to create a bearing depends in general upon being able to generate a separating force between a moving element and a stationary element. A current generates a magnetic field around a wire, this field in turn creating eddy currents in the superconductor, thus producing an opposing field. Thus the magnetic field from the wire is compressed and distorted between the wire and the superconductor. These opposing fields, or the compression of the magnetic flux lines, result in a force on the conductor tending to lift it above the superconductive plane.

Cryogenic superconductive bearings have been tested by the General Electric Co., U.S.A. The principles on which they operate are well understood, and bearing supports can be engineered by application of these principles. The forces generated are normal to the bearing surface so long as the surfaces are superconductive, and there is therefore no resistance to lateral motion, the friction coefficient being zero. The forces that can be generated are limited by the critical magnetic field of the superconductor, and are relatively small using available materials.

THE DECEMBER ISSUE

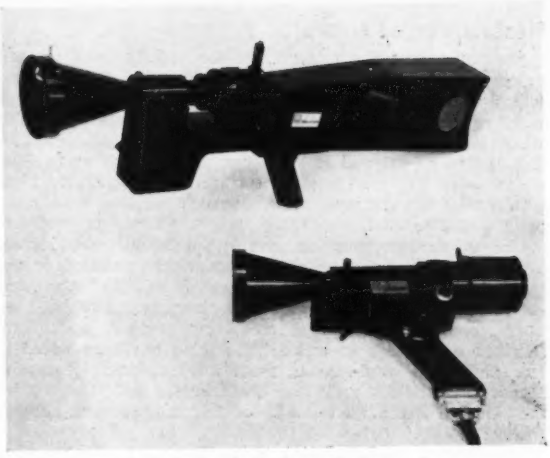
of *Engineering Materials and Design* will include the following main features:

Vacuum Pumps — Their Characteristics and Selection
Survey of the technology, characteristics and accessories of modern vacuum pumps.

Combating Self-excited Rotor Vibration
Showing how to deal with the problems arising from self-excited rotor vibrations initiated by the action of the lubricating film in journal bearings.

Design Approach to Ground Effect Machines
Dealing with some of the problems associated with various design configurations.

Design Methods with Thermoplastics
The author explains how far it is possible to use standard methods of design when dealing with thermoplastics.



Infra-red Communications System

MINNEAPOLIS HONEYWELL have developed a portable self-contained infra-red communications system called Maxsecom, designed for a range of approximately 1,500 ft. Included in the system, which is initially for evaluation, is a method of "closed loop" self alignment, by which each station may align itself with its own re-transmitted signal for optimum communication. The principle on which this form of communication depends is that of infra-red modulation by means of a germanium cell, the system of communications consisting of two portable self-contained transceivers, each with its own dual receiving and transmitting optics and electronics.

The transmitter consists of a germanium transducer irradiated by a fixed source of infra-red radiation. Modulation is accomplished by a two-stage transistorised power amplifier, whose push-pull output is transformer coupled to the germanium modulator. The power amplifier, furnishing one watt of power for 50% modulation, is driven by one of three input signals, depending on the mode of operation.

The receiver consists of a 3-in. objective lens, at the focal point of which is a PbS detector whose output is coupled to a high gain transistorised amplifier. Optical gain is made very high due to the high ratio of lens area to detector area. The output of the amplifier is coupled to a set of earphones. The accompanying photograph shows both transmitter and receiver.

Electrification Problems

A THREE-CAR TRAIN was recently specially fitted up as a mobile laboratory by General Electric Co. Ltd.. to establish the working conditions of the high-voltage electrification on the N.E. lines of Eastern Region. One of the main instruments in this unit was a Remscope (transient storage oscilloscope), designed and made by Cawkell Research and Electronics Ltd. Its application during this period of testing was mainly concerned with the detection and measurement of voltage surges in the power circuits of the Multiple Unit Stock operating on 6·25 kV. sections of the Eastern Region, which have been associated with the recent failures of the new rolling stock.

According to reports, the considerable number of traction motor failures (83% with one make and 100% with another) has been due to faulty insulation. It is believed that the insulation adopted incorporated silicones, and that the fault lies not with the material but with the process of application. If this is the case, it is to be hoped that traction motor manufacturers will heed the warnings recently published in *Engineering Materials and Design*, by Mr. W. Duckett (February, March and April, 1961). It would be interesting to ask the manufacturers such questions as:

1. Are design office instructions being carried out correctly?
2. Is the designed compression of the insulation being correctly applied? (Too much compression squeezes out the varnish and shatters the glass fibres, and too little compression fails to consolidate the materials.)
3. Are the correct drying and baking times and temperatures being observed?

Flexible Winged Aircraft

THE RYAN AERONAUTICAL CO., of the U.S.A., have recently completed the first proving flight of a prototype Flex Wing, which uses wings of a flexible material. Unlike the rigid metal-covered surfaces of the conventional aircraft, the flexible wing is made of plastics-coated nylon material, which is attached to a keel and leading edge members, so as to form an arrow or V-shaped kite-like surface. For high-speed high-temperature applications, materials such as fine wire mesh cloth would be used.

The wide range of applications of the flexible wing include both manned and unmanned vehicles, either powered or unpowered. In size they may vary from small powered reconnaissance drones manœuvered by remote control, to huge unpowered wings capable of recovering payloads and rocket boosters of 50 tons or more. The wing has been tested in free flight and wind-tunnels, from low subsonic velocity to speeds of Mach 4.9, and from low altitudes to 200,000 ft., by the National Aeronautics and Space Administration, at Langley Field, Virginia.

The span of the test vehicle is just over 39 ft., with a wing area of 555 sq. ft. when fully deployed; the engine is of 100 h.p. According to the makers, the outstanding feature is the lack of artificial stabilising surfaces, the wing being an extension of the principles first explored by Leonardo da Vinci.

Helicopters towing the flexible wing as a glider will be able to transport six times as much weight in troops, cargo or fuel as the helicopter alone can carry. In this way helicopter capability will be greatly expanded, enabling large amounts of cargo to be transported.

The Flex Wing is said to be a remarkably stable, simplified inexpensive concept providing greater lift per unit of weight than conventional wings or parachutes. Its flexible characteristics permit it to be conveniently folded and stored in a small package the length of its keel.

Clad Tube

VERY LITTLE ATTENTION has been given to the production of clad metals in forms other than clad plate, sheet and strip products. A composite or clad tube which combines dissimilar metals by molecular bonding process has been developed by the Allegheny Ludlum Steel Corp.

By combining the Ulam process for bonding metals and the Ugine-Sejournet hot-extrusion process, composite tubing having a high-strength inseparable bond can now be made. This composite tubing meets many of the corrosion resistance requirements of the chemical, petroleum and nuclear industries, and it can be fabricated in the same way as a solid product.

The high-strength ductile bond of composite tubing permits hairpin bends, flaring and fabrication of fittings without separation of the two metals. The shear strength of the bond between the dissimilar metals is more than 45,000 p.s.i. This strength is attained with many metal combinations—stainless steel and carbon or low alloy steel, Inconel, and many others.

Wire Rope Lubrication

WIRE ROPE LUBRICATION serves two main purposes: to prevent internal corrosion and deterioration which cannot be properly evaluated by external inspection; and to save the cost and time of maintenance or replacement of both the rope and its associated equipment, such as sheaves and drums.

Corrosion in the wire rope is doubly harmful; it decreases the diameter of metal in the individual strands and, furthermore, leads to the formation of powdered rust which lodges between the strands and increases the extent of abrasion, thus accelerating the loss of metal even further.

The oils which are originally present in the fibre core of new wire rope are partly deteriorated by oxidation and partly squeezed to the surface under changing tensions and stresses. Once the oil reaches the surface of the rope, it is eventually eliminated by wiping action, or rendered useless by mixing with dirt.

Accompanying this decrease in core lubricant is a significant decline in the useful life of the rope, and it can be shown quantitatively that external lubrication of wire rope maintains the equilibrium lubricant concentration of the rope core, and preserves the core fibres for a longer period of time, thereby maintaining the rope in good working condition. Furthermore, external lubrication during use greatly reduces internal friction between the component parts of the rope, as well as between the rope and equipment to which it is applied.

It has also been established that dry fibre cores have a tendency to absorb moisture from the air with a resulting increase in the rate of corrosion. This tendency can be suppressed by supplying an adequate amount of lubricant during use.

Heavy-bodied lubricants provide an excellent seal against moisture penetration and against attack by acid or caustic fumes, the drawback being that they congeal almost immediately upon contact with the rope's surface. Their function is thus essentially only to form an external sheath which reduces loss of internal lubricant. The current trend is toward more extensive use of light lubricant oils. By applying the lubricant at a bend in the rope's travel, where the strands are slightly opened, penetration right into the interior of the rope is facilitated.

Corrosion-resistant Tape

IT HAS BEEN ESTIMATED that, in Britain alone, corrosion costs industry £600 million every year. This sum can be substantially reduced if sufficient thought and planning are devoted to anti-corrosion methods during the design stage of any engineering project. While metals can be protected from corrosion by the application of special paints and coatings, which can be supplemented if necessary by the use of cathodic protection, it is interesting to note the increasing use of protective tapes in the fight against corrosion. These can be applied cold, on site, and have proved to be an effective and economical proposition where long-term protection is considered, or where metal structures in inaccessible positions have to be protected.

At a large gas-producing plant, metal hand-rail supports along gangways and inspection platforms were always having to be re-painted, since no paint system could withstand the destructive effects of the highly corrosive acid-laden atmosphere. A black p.v.c. plastics adhesive tape, 0.008 to 0.009 in. thick, supplied by Rotunda Ltd., was wound on spirally with a reasonable overlap without tension. Now, after two years, the tape and the hand-rails are still in excellent condition, and maintenance costs have thus been reduced.

In a similar way, this tape is being used for the protection of overhead pipelines subject to corrosive fumes. Before the tape is applied, it is always necessary to remove any loose scale or dust, to ensure perfect adhesion.

Pressure-sensitive adhesive p.v.c. tape can be supplied in accordance with British Standards Specification, the self-adhesion characteristic being extremely important for corrosion prevention. It is absolutely vital that the tape should cling cohesively to the pipe and to the underlap.

P.v.c. plastics adhesive tape is highly resistant to the flow of stray galvanic currents, and for this reason can be used for the protection of electric cables buried in corrosive soil, or where there is a danger of stray currents.

THE HUMAN ELEMENT IN INDUSTRY

A NEW LOOK AT EDUCATION

IT is an encouraging sign to find that there are leaders among men who are gradually but surely awakening to the knowledge and conviction that a Christian attitude of mind must once again become a living force in the daily lives of mankind, and that we must recognise in one another the frailty of human nature and be ready and willing to make allowances, and to amend an error or mistake, recognising that "to err is human, to forgive divine". It is small wonder that the educational authorities are sorely perplexed as to the procedure to lay down, and that even universities have under consideration the question as to whether students should be made to follow a prescribed course of study, or whether the curriculum should coincide with the natural bent of each student. There is doubtless much wisdom in this, because it will avoid what has so often happened in universities, colleges and schools—much valuable time being spent and wasted in teaching certain subjects in which the student has no apparent interest, and which he is never likely to learn.

It is for this reason that large numbers attain the adolescent stage devoid of any positive knowledge which can be immediately applied to the task of earning a living. Very often they have to start, as it were, from the beginning again, and in consequence set off with a serious handicap—that of having an inferiority complex.

An inferiority complex is a grave malady. The tragedy is that so very few realise they have it until faced with the problem of being in contact with other people, for it is then that educational advantage asserts itself. It is equally true, of course, that any disparity may be imaginary—this is very often the root cause of the complex. Many men have gone right through their whole life without being able to rid themselves of it. Those who succeed often do so late in life, and only then when a very trying experience has proved a testing time for mental and physical endurance and fortitude, and when it has become a question of fighting back to regain sanity of mind. In short, when a man has had to be an individualist, independent in spirit and achievement, but yet able to make a positive contribution to human fellowship.

Commonplace decisions are multitudinous in their application and influence on the lives of others, and often of more educational value than any school curriculum, which is too frequently centred on historical records and the lives of those who are dead. What is more important is that people should be taught about the events of the present day, and the new circumstances which have arisen during the twentieth century, wherein human progress has advanced at a tremendous pace, and revolutionary changes are occurring almost daily.

It is a truism that no circumstance is without its redeeming feature, and that there is no task immediate or ahead of us that does not contain an interesting opportunity—it is as well that each one of us should be looking for that opportunity. But how very difficult it is for a man to accept an opportunity unless it is presented in such a way and with such prospects as are deemed necessary to satisfy his own conceit! Nevertheless, the passing of an opportunity can often be the means of losing something tangible and invaluable. Unfortunately, the lack of insight into one's own life too often blurs one's vision of possibilities in the future.

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Engineering Materials and Design

THE MOUNTAIN TO MAHOMET

FREE interchange of ideas between specialists, between manufacturers and users, and between designers and all whose work affects design, has become one of the most important factors in industry today. With the continuing advances in science and technology, the designer cannot be expected to have specialist knowledge of all the subjects which concern his work. He must however keep in touch with the specialists who develop new materials, new equipment and new production techniques, so that the products he designs are up-to-date in all respects.

Sir Miles Thomas suggested recently that the best way to achieve interchange of ideas was through the medium of technical associations. For some time we have been thinking along similar lines, and the Engineering Materials and Design Association was formed as a natural development of the journal's policy of disseminating information of interest to the designer.

From the beginning we have never regarded *E.M. & D.* as just another technical journal to be read. We believe that it offers a great deal more to the individual reader than most journals, not only through its reader enquiry service but by having a genuine interest in real design problems, and it is highly satisfying to learn that our activities are appreciated by a large body of readers. An example of how our encouragement and advice can help followed the publication in the December 1960 issue of details of a new self-lubricating material. We are happy to know that following this reference, a manufacturer has now taken up the invention, and intends to put it on the market in the near future. The inventor told us that were it not for our encouragement at a stage when no-one seemed interested he would have dropped the whole idea.

Our philosophy may be summed up in the phrase: "We aim to take the mountain to Mahomet", and the *E.M. & D.* conferences and exhibitions at Earls Court are part of this aim. To support this aim the Engineering Materials and Design Association is holding its first technical session at Buxton in March 1962—this will be followed by a visit to the A.S.M.E. Design Conference and exhibition, which is to be held in Chicago by the American Society of Mechanical Engineers in May 1962. In the Autumn of 1962, we are holding a three-day symposium in the West country. In this way we not only move into the areas which are most likely to benefit by such conferences, but we are also able to bring together the designer, the specialist and the supplier of basic materials and components. Thus the designer can obtain the best from that which is available, and the supplier can find out what to supply.

We hope for the sake of British leadership in engineering that companies will recognise the need to create a common market for the dissemination of knowledge and technical information.

It has often been said that it is impossible to justify the expenditure of time and money to attend all, or even a few of the available conferences. This is quite true on a short-term basis, and it takes only a few years to realise that in this way the engineer becomes hopelessly out of touch with relevant developments. Perhaps it is time that someone looked closely into the question of whether there are too many exhibitions and conferences, and what their relative values are.

Nevertheless, engineering creativity starts in the design office, and it is to the designer that attention must be given. This is the aim of *E.M. & D.*, and its Association. It is also a major interest with our new sister paper *Engineering News*, which has made such a tremendous impact on the engineering world.

Because of increasing competition from other countries, and the fact that "British is Best" is no longer a selling tag, the need for information is today greater than it has ever been, and the right prices, realistic delivery dates, and an adequate after sales service are essential factors. To prove that British goods are the best, we first have to make them so.

The Editor

TEMPERATURE – INDICATING PAINTS AND MELTS

After commenting on Seger cones, the author discusses ways of using the various other types of temperature indicator, and deals with application procedure, readability, and assessment or errors

by DR. JAMES MILLER*

ONE of the early problems confronting engineers was the estimation and reproduction of specific heats in inaccessible places, such as the centre of a kiln or furnace. In ceramics there is evidence that in the eighteenth century Josiah Wedgwood used a type of pyrometric cone, and the Sèvres potters were using them in 1884. In 1886 Heintz made cones of glass mixtures, and in the same year Seger built up a series of mixtures from cone No. 1 (softening about 1,150 deg. C.) to No. 36 (softening around 1,700 deg. C.). Eventually the series was extended by Cramer and others to lower and to higher temperatures. Of more recent origin is the method of determining the thermal change by the use of substances which, at given temperatures, either fuse or change colour.

Seger Cones

The original German Seger Cones were invented by Dr. Hermann August Seger, of the Royal Porcelain Factory at Charlottenburg. Later similar or modified versions have been produced by various manufacturers, the term "Seger Cones" having been retained. These cones consist of a mixture of calcium carbonate, kaolin and quartz, the percentages varying to obtain a melt in fifty-nine or more temperature ranges between 600 and 2,000 deg. C.; thus they register in steps, plus or minus, of approximately 23 deg. C., but they should not be regarded as recording definite temperatures but as a means of measuring "heat-work".

In use, the practical method of ascertaining the temperature of ovens and kilns is to place the cones in different parts, in such a position as to be visible through the sight holes provided for the purpose. Three or preferably four cones registering below, at, and above the desired temperature should be used in as many positions as possible, because the temperature in a kiln or oven is rarely uniform throughout.

The cones are mounted on a refractory stand, and placed about $\frac{1}{4}$ in. apart with the surfaces bearing the numbers in line and at an angle of 15° from the perpendicular. This angle allows the cones to bend backwards so that the numbers are always visible. The lowest rated or "signal" cone, by fusing, will indicate that the oven or kiln is nearing the temperature to which it should be fired and that the firing must now proceed with care; the middle rated or "critical" cone, by bending backwards so as to touch the base plate with its apex, will be the cone indicating the temperature to be fired to, while the highest rated or "sentinel" cone, by remaining erect, will show that the kiln or oven has not been overfired (See Fig. 1).

Precautions

For the cones to function successfully they must be tilted as described above, and must be in their base plate or socket. They should be protected from the direct action of the flames and gases, and must not be flashed or subjected to dust or to currents of cold air from the sight hole. They may be protected by placing bricks around three sides, taking care that the cones are all at the same distance from the bricks or the walls of the saggar or muffle. Other types of Seger cone in present-day use are:

1. Pellets melting at stated temperatures. The effect of the fire on the pellets is first to dull the corners, next to round them and finally to melt them into a mass having a slightly concave surface. The key pellet is that one which has become slightly rounded on the edge.
2. Cylindrical bars of fusible material about $2\frac{1}{2}$ in. long coloured at one end for identification. They are placed vertically in their sockets, and on firing they bend and then melt down as the heat rises. The coloured end remains after fusion, allowing their rated temperature to be recognised.
3. Bars of different melting points placed horizontally on miniature trestles. On reaching the temperature to be fired to, the critical bar sags in the middle.

All these methods are variations or adaptations of the Seger principle and all require the precautions stated above, without which the readings and interpretations will become unreliable. It is better to master one type and to keep to it, thus minimising the personal error.

*A. Levermore & Co. Ltd.

Thermal Colour-change Paints

These paints possess the property of changing their original colour when their individual temperature rating is reached or exceeded. The changes are quite pronounced, some having only one colour change, others as many as three or four changes through a range of temperatures. The paints are in powder form, and have to be pasted with alcohol to the desired consistency for use either by brush or spray gun. Objects to be painted must be thoroughly cleaned, and all traces of oil or grease removed by alcohol. The paint should be thinly applied, as too thick a coating tends to peel off. Before subjection to heat a reasonable time (30 min.) should be allowed for the paint to dry. Should blistering or flaking be experienced, good adhesion of the coat can be obtained by the use of a special binder.

Table I. Typical range of thermal paints

Original Colour	Changed Colour	Colour Change Temperature (°C.)
With One Colour Change:		
pink	blue	40
light green	blue	60
pink	blue	80
pink	lilac	95
yellow	violet	110
purple	blue	140
blue-green	black	165
white	brown	175
green	brown	220
yellow	red-brown	290
white	brown	340
green	white	440
red	light grey	520
red	yellow	560
yellow	light green	640
yellow	olive	715
biege	brown	805
grey	dark brown	900
green	brown	1,000
light blue	blue-black	1,100
grey	black-brown	1,200
light grey	brown	1,260
grey-yellow	black	1,350
With Two Colour Changes:		
light pink	light blue	65
light blue	light brown	145
grey-green	yellow	145
yellow	black-brown	220
blue-green	yellow-brown	190
yellow-brown	black	340
blue	yellow-brown	240
yellow-brown	black	340
green	lilac	1,165
lilac	black-green	1,235
With Three Colour Changes:		
grey-green	light blue	65
light blue	olive-green	145
olive-green	black-brown	220
pink	yellow	145
yellow	grey	175
grey	olive-green	340
yellow	black	175
black	violet	290
violet	brown	340
yellow	orange	420 reversible
orange	grey	700 reversible
grey	brown	820
With Four Colour Changes:		
pink	light blue	65
light blue	yellow	145
yellow	black	175
black	olive green	340
light green	light blue	65
light blue	yellow	145
yellow	black	220
black	black-brown	340

Fig. 1. Range of four Seger cones in use. (Harrison & Son (Hanley) Ltd.)

The one-colour-change paints are made in twenty-three types from 40 to 1,350 deg. C., and those with two-colour-change are available in six types. Three-colour-change paints may be obtained in four temperature ranges, and four-colour-change paints in two temperature ranges.

Temperature Determination

If the range of temperature to be determined is unknown beforehand, a general idea can be obtained by applying the multicolour-change paints and then sub-dividing their temperature range with single-colour change paints. The colour changes shown in Table 1 apply to heating periods of approximately 30 min. Should the colour change occur in a shorter heating period, a somewhat higher temperature paint is required, and a somewhat lower temperature paint should the heating period be longer. In order to avoid erroneous readings, it is thus necessary that the heating period should be about 30 min. from the commencement of warming until the part attains the colour change temperature. When testing temperatures based on the heating period mentioned, the tolerance is plus or minus 5 deg. C., which is precise enough for most practical purposes.

The influence of atmospheric moisture causes the changed colours of some of the paints in the lower temperature ranges to revert gradually. If they are damped the colours will revert suddenly, and the original colours will reappear. In general these paints cannot be used under water, or in steam and in the presence of certain gases.

Most of these paints are inflammable, and should be handled with care, particularly when using a spray gun. Some contain lead compounds, and therefore should be applied with the usual precautions. When brushes are used it is advisable to identify and keep one brush exclusively for that particular paint.

A simple test to illustrate the action of these colour change paints is to paint or spray a cooker hot-plate with a three-colour-change paint. When the paint has dried the plate is heated. As the temperature rises the colour changes are clearly shown by the three isotherms which form, and even the delays in heat transmission caused by the air between the rings of the plate frame are demonstrated (Fig. 2).

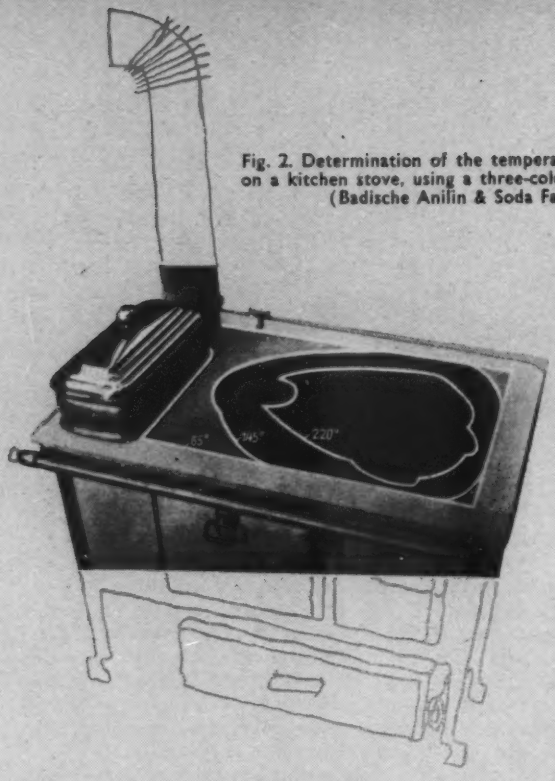


Fig. 2. Determination of the temperature distribution on a kitchen stove, using a three-colour-change paint. (Badische Anilin & Soda Fabrik.)

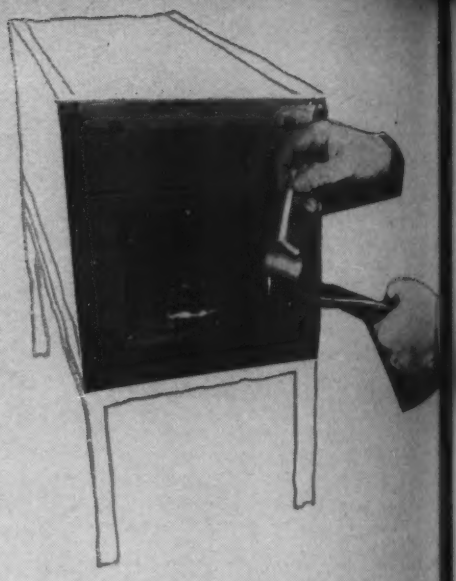


Fig. 3. Checking the preheating of a sleeve with a thermo-e (Badische Anilin & Soda Fabrik.)

Applications

The use to which these paints can be put is varied and extensive, and will depend to a great extent upon the ingenuity of the engineer when intricate heat problems have to be overcome. The following examples give some indication of their versatility.

When several burners are in operation, in a limited space, it is often impossible to determine quickly any burner which flashes back. A typical example of the use of these paints is where both burners of a small melting tank were treated with a single-colour-change paint having a critical temperature of 340 deg. C. One burner, as the result of a flash back, experienced a rise in temperature to above 340 deg. C. and a change of colour in the paint, thus immediately warning the operator to take the necessary action; the other burner still had the original warning coat, showing that it was functioning in a normal manner.

Another application where these paints have been successful is in the dry sterilisation of surgical dressings and instruments. Metal drums containing dressings to be sterilised were given a smear of the paint in the temperature range required for sterilisation. They were then placed in the steriliser and "sterilised" for the usual time. On removal and examination of the drums no colour change of the paint was noticed. The drums were replaced in the steriliser and subjected to a further period of sterilisation of several hours duration. The drums were again removed and examined, and it was noted that the paint on the peripheral drums had undergone a change of colour while those in the centre remained unchanged, clearly warning that the dressings in the centre of the steriliser had not reached sterilisation-temperature-time. In the larger sterilisers it was found that sterilisation had to be carried out for at least 12 hr. before the paint on the central drums underwent the colour change. These findings are rather startling, and show the fallacies that can arise when relying entirely on external temperature measurement.

Thermal Colour-change Crayons

These crayons enable temperature to be determined and controlled in the thermal treatment of plastics, light metals, glass, etc. They possess the property of changing from their original colour to another distinctive colour upon reaching the temperature for which the particular crayon is designed. The colour change is permanent, i.e. it does not revert to its original colour upon cooling. These crayons are available in various colours through the range 65 to 670 deg. C., in stages of from 10 to 100 deg. C.

Method of Use: If the object under process has already reached the "change temperature" of the crayon being used, then the colour change takes place 1 to 2 sec. after the mark has been made. If this occurs while the mark is being made, the object has already exceeded the measuring temperature of the crayon. If the colour change takes place later than 2 sec. afterwards, then the temperature is still below the measuring value.

Surface Temperature Indicators

A great deal of work has been done on the development of temperature measuring instruments, including the glass-tube-thermometer type, the electrical pyrometer (such as the resistance voltmeter using thermocouples), and optical and radiation pyrometers. All can be immersed either in liquids, solids or gases.

Optical pyrometers provide accurate determination on high-temperature heats in the range of 705 deg. C. and upwards, but on many occasions errors creep in due to intervening gases in the furnace. When dark heats are used, i.e. at temperatures up to 595 deg. C., the optical pyrometer is useless.

As is well known, the ordinary glass thermometer when placed on the surface of the metal will not give true temperatures of the surface, because only one imaginary line of the bulb is in contact with the metal. The rest is open to radiation in the air. A flat contact thermocouple can be

used to determine surface temperatures, but here again it is very erratic because the reading is influenced by the contact pressure between the thermocouple and the surface. The same operator may secure different readings up to 10 deg. C. apart, because he cannot determine the exact pressures he is applying to the surface with the contact thermocouple. Other errors are liable to occur when the surface being measured is rough or curved.

To overcome some of these problems, research was undertaken on chemical compounds which would signal surface temperature by instantaneous and accurate melting of the compounds at specified temperatures. The end result was the production of a surface temperature indicator, in stick, pellet and liquid form, which is easy to apply, easy to interpret and accurate to 1 per cent. It covers a range of from 45 to 1,095 deg. C. in steps of 12 to 50 deg., and further research is expected to extend this range to 1,650 deg. C.

Chemical signals, unlike thermocouples, are not affected by high voltage or static electricity; they operate very simply and efficiently. All that has to be done is to mark the surface with the stick, brush the surface with the liquid, or place the pellet on the surface to be identified. As the surface reaches the stated temperature the chalky mark melts and forms a liquid glossy smear, clearly indicating, both by a change in the structure of the mark as well as by the colour, the specific temperature. This instantaneous change on all surfaces has an advantage over the pyrometer and heat-sensitive colour-indicating paints. It clearly signals the surface temperature to the operator within a fraction of a second.

With the rapid advance of technology, and the discovery and development of new metals and alloys to provide protection against extreme temperatures in atomic submarines, missiles, rockets and space vehicles, it has become necessary to provide more accurate means of temperature determination in order to produce weldments which will not crack or embrittle at high pressures and temperatures. Pre-heating of metal prior to welding, and post-heating after welding, has become a major factor in controlling the welding processes and eliminating the danger of cracks developing in the weld metal or the adjacent base-metal zone (see Fig. 3).

One of the newest and most interesting adaptations of temperature-indicating compounds in stick form is that now being used in conjunction with the American HY-80 steel developed for use on nuclear-submarine hulls, to withstand great pressures in deep water. For the successful welding of this steel the materials require pre-heat, which must be limited to 150 deg. C. in order to: (a) maintain the weld nugget's quench rate; (b) obtain desired mechanical properties; and (c) prevent degradation of the heat-affected zone (see Fig. 4).

Another interesting development with these sticks has been their use on fusing plastics pipes to their fittings, where care must be taken to prevent overheating or underheating when assembling plastics pipes by fusion. Engineers responsible for steam trap maintenance can detect faulty traps by stroking the correct indicating stick (depending on the steam temperature being used) on the trap outlet. If the chalky mark turns to a liquid glossy smear, it alerts the operator that the trap is faulty and is blowing steam. For example, if steam at 150 deg. C. is going through a trap that is blowing, the temperature of the inlet and outlet will be the same, and a 150 deg. C. stick will melt on contact with the outlet, thus indicating malfunction of the trap. When the trap is functioning properly the inlet will be at 149 deg. C., while the outlet will be about 120 deg. C., depending upon the system.

In welding, these sticks are being increasingly and successfully used as a necessary aid to control the pre-heat welding

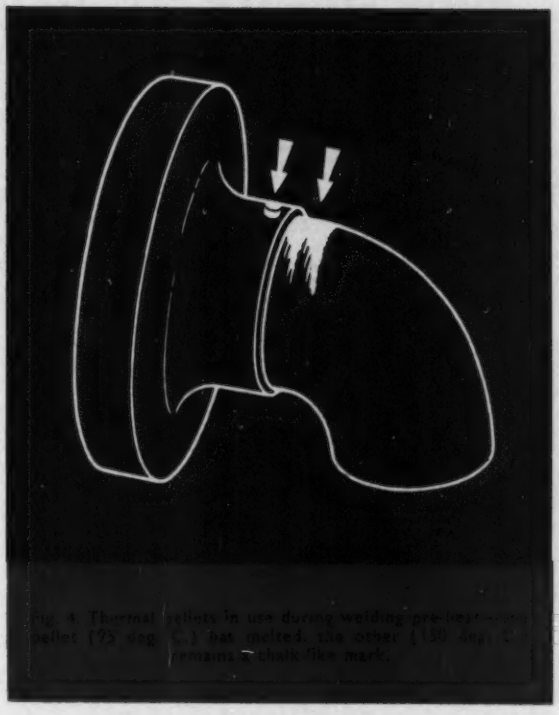


Fig. 4. Thermal pellets in use during welding pre-heat ... pellet (93 deg. C.) has melted, the other (150 deg. C.) ... remains a chalk-like mark.

temperature, to provide optimum conditions for strength, toughness, ductility, shock, corrosion, resistance, and minimisation of distortion and shrinkage in the welded parts.

In water-cooled motors, which usually have an optimum running temperature, the correct functioning of the thermostat can be determined. Should the operating range of the thermostat be between 52 and 73 deg. C., and if a 52 deg. C. stick when applied does not melt then the engine is running too cold. If a 73 deg. C. stick melts, then the engine is running too hot, so an adjustment one way or the other of the thermostat is indicated.

Temperature-Indicating Liquids

These liquids are ideal for hard-to-measure, inaccessible and vertical surfaces, and for smooth surfaces such as glass, plastics and polished metals. In steel mills they are used in controlling the temperatures of open-hearth ingot-moulds, to determine the surface temperature of metals and thus to avoid accidental burns to operators. In the rail-road industry the paints help in checking bearings to prevent overheating "hot boxes"; in the electrical industry they are used to warn that metal oxidation is taking place in electrical connectors.

Conclusion

The few examples given have shown the versatility of these surface temperature indicators, and no doubt many more practical instances will arise in the future in which their application will become an essential part of production in industry.

The author wishes to thank the following manufacturers and agents for their help in compiling this survey: Markal Company, Chicago (Dr. Aronberg); A. Levermore & Co. Ltd.; Wengers Ltd.; Harrison & Son (Hanley) Ltd.; Allied Colloids Ltd.; Headland Engineering Developments; The Amalgams Co. Ltd.; Victor Products (Wallsend) Ltd.; The Ingalls Shipbuilding Corp., U.S.A.; Badische Anilin & Soda Fabrik; and A. W. Faber-Castell, both of Germany (the U.K. agent for these two firms is Allied Colloids Ltd.

LIQUID METALS AS HYDRAULIC FLUIDS

This article is made up of extracts from a paper by Kumpitsch and Granan (of General Electric Co., U.S.A.), presented at the sixteenth annual meeting of the National Conference on Industrial Hydraulics

A TREMENDOUS effort is being made in the development of organic and inorganic hydraulic fluids, and the advances are highly encouraging. However, there is at present no fluid which can operate successfully above 760 deg. C.

Pneumatic systems, on the other hand, do not suffer from fluid deterioration with temperature, but they do have other unique problems. Missiles, for example, would be seriously penalised if they were required to carry high-pressure high-temperature gas storage bottles. Hot gas servos, operating from powder grain, are at present limited to several minutes of operation.

The inherent advantages of a hydraulic system—high response, stiffness, high power-to-weight ratio, good efficiency and compactness—make this type of transmission particularly desirable for long flights at temperatures in the 550 deg. C. region, if a satisfactory fluid is available. For this reason the Directorate of Materials and Processes of the Aeronautical Systems Division has sponsored an investigation of liquid metals as power transmission fluids.

Selection of a Suitable Liquid Metal

By definition, liquid metals are those having a melting point below 660 deg. C., although this is not a very practical definition. In selecting a liquid metal for hydraulic control, primary interest is in materials with a low melting point, wide operating range and reasonable availability. Other considerations are cost, density, stability, toxicity and compatability with other materials.

The development of nuclear power plants has been accompanied by a study of the alkali metals, particularly sodium and sodium-potassium alloys. While most of this work has been in connection with heat exchanger loops, much of it is directly applicable to power transmission systems.

A review of this material led to the conclusion that the liquid metal having the best possibilities was the eutectic alloy of sodium and potassium, commonly known as NaK-77. This alloy is available in unlimited quantities, and is reasonable in cost.

Fluid Characteristics

NaK-77 melts at around −12 deg. C. and boils at about 790 deg. C. Its melting point is somewhat higher than the ideal, but the high boiling point makes this a minor limitation for many applications.

The viscosity of NaK-77 is very low, being somewhat below that of water at room temperature, and dropping to about 0·20 centistokes at 760 deg. C. On the other hand, it has a very flat viscosity index over its liquid range.

The lubricating value of NaK is generally considered to be very poor, its fluxing action tending to remove any oxide coating which might conceivably act as a lubricating medium. Under certain conditions NaK oxides may be generated, and these have a mild abrasive action, but the general engineering laboratory of the General Electric Co. has conducted tests which indicate that it is possible to maintain a hydrodynamic film in NaK lubricated bearings.

NaK, like other alkali metals, reacts with moisture and oxygen. This has been considered as a major deterrent in utilising NaK as a hydraulic fluid, although it would be more fair to say that NaK requires special techniques and precautions in order to take advantage of its other outstanding qualities.

Bearing tests indicate that NaK lubricated bearings have a relatively high coefficient of friction, and there is some evidence to show that this may be due to the high shearing strength of a NaK film, as well as the fluxing action of the metal. NaK-77 has the widest operating temperature range of any hydraulic fluid now available ; it can operate successfully from –12 to about 790 deg. C.

The compressibility of a hydraulic fluid is a vital factor in the design of a servo system. Here, NaK-77 should be an outstanding performer. With a bulk modulus of 750,000 p.s.i. at 38 deg. C., it still retains a value of 225,000 p.s.i. at 540 deg. C.

With protection against oxygen contamination, NaK is one of the most chemically stable hydraulic fluids. It undergoes no deterioration or degradation over its entire liquid range, and maintains this stability at continuous high temperatures. Its resistance to nuclear radiation has been well established by actual use over long periods. The density of NaK-77 is comparable with other hydraulic fluids. It has a specific gravity of 0·88 at –12 deg. C., and 0·70 at 760 deg. C.

The high thermal conductivity of NaK is a definite advantage in liquid metal lubricated bearings, where reduction in wear from localised heating is considered. This advantage is due to the superior thermal conductivity of NaK.

Design Problems

The behaviour of liquid metals in high-temperature systems gives rise to several unique problems, and although these are by no means insurmountable, they do require careful design and a judicious selection of materials. Perhaps the most important problem is that of mass transfer, which may be present as :

1. Thermal gradient transfer, in which the solubility of a material in liquid metal varies with temperature.

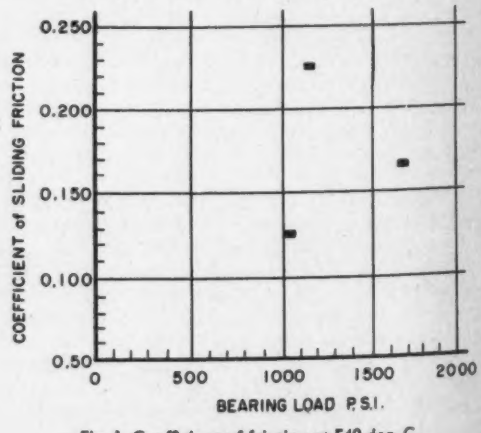


Fig. 1. Coefficient of friction at 540 deg. C.

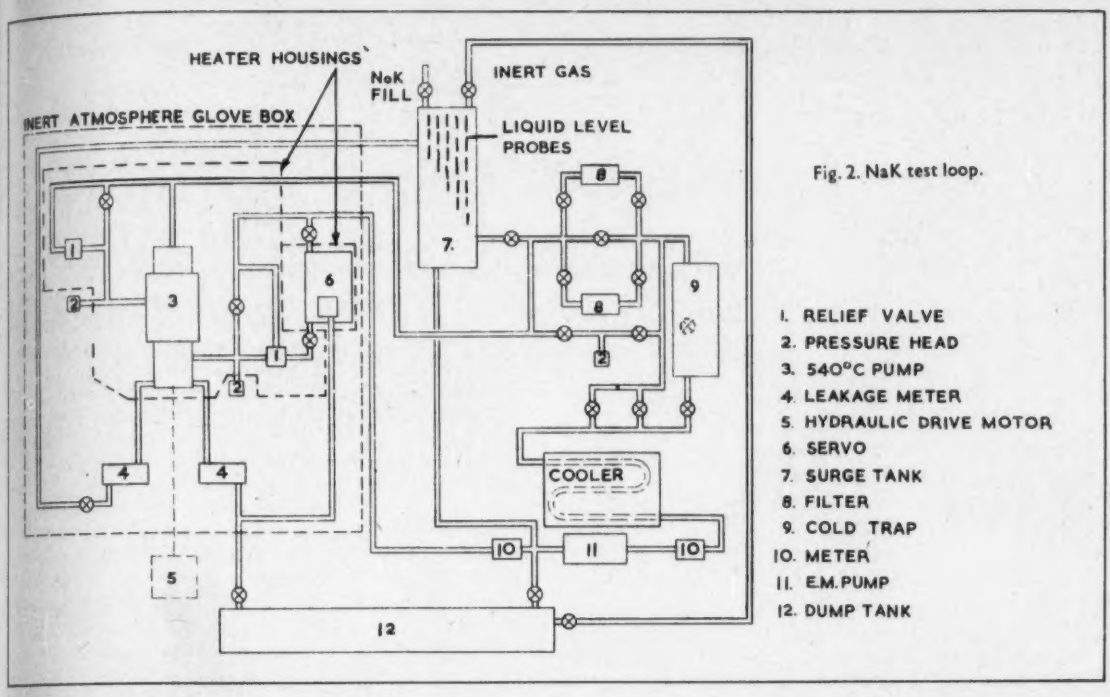


Fig. 2. NaK test loop.

2. Chemical gradient transfer, in which the principal factor is the reaction of a solute in the liquid metal with a solid in contact with the solution. This can be minimised by a proper selection of materials.

Diffusion welding is the result of the fluxing action of NaK, which removes oxides and thus promotes intermolecular bonding. Temperature and materials are both factors in welding. It is not particularly troublesome below 540 deg. C., and above that temperature it can be eliminated by the use of dissimilar materials in contact areas.

Corrosion in liquid metals is a complex subject, and may involve transfer of materials; alloying between liquid and solid metals; simple solution; intergranular penetration; and impurity reactions. In all of these, temperature and temperature gradients play an important part. Fortunately, corrosion is receiving widespread attention, and as its nature becomes known, more and more design criteria are being established.

The ideal liquid metal system would have no thermal gradients, it being preferable to keep a system as uniformly hot as possible. A perfectly clean and perfectly sealed system would have little trouble with gradients. But since it is impossible to remove all the oxygen from a system, it is particularly important to maintain a temperature above the saturation temperature of the oxide content.

The requirement for an inert gas cover comes about largely because of the affinity of NaK for O_2, and because practical hydraulic systems cannot be hermetically sealed. Dry nitrogen, or preferably argon, is generally used to fill the space above the liquid metal in reservoirs and drain tanks.

Investigation of material compatibility and wear resistance in NaK-77 at 540 deg. C. was conducted on friction and wear test equipment, the materials evaluated being primarily carbides, since previous studies had indicated that ceramic-type materials provided the best results in NaK at 540 deg. C. Five material combinations were evaluated by testing for 5 min. each. The three best material combinations were re-evaluated for a 6-hr. period at 540 deg. C. The characteristics determined from these tests are shown in Fig. 1.

From this evaluation the material combination selected for the design of a high-pressure pump was the mixed tungsten-titanium carbide running on a titanium carbide. This is represented by the middle point. This combination possessed the highest load-carrying capability and consequently the lowest wear. It also maintained a reasonable friction coefficient and demonstrated the best wear surface finish.

A continuous-flow liquid metals test loop, to pump NaK-77 at 3,000 p.s.i. and 540 deg. C at a continuous flow rate of 1 g.p.m., has been constructed. The results of the preliminary investigation conducted with both the single-piston pump and friction-wear test equipment were used to good advantage in the design of this loop, which is shown diagrammatically in Fig. 2.

Conclusions

The test programme is intended primarily to investigate the feasibility of using liquid metals, especially NaK-77, as a hydraulic fluid in a 540 deg. C. ambient. A hydraulic servo was included to demonstrate control operation, rather than as a means for evaluating servo performance. From the tests conducted to date, the following conclusions have been arrived at:

1. NaK-77 behaves in an entirely predictable manner.
2. NaK-77 is adaptable as a hydraulic fluid from –12 to 760 deg. C. since it remains a liquid over this range.
3. NaK-77 shows no signs of deterioration with temperature or time in a closed system.
4. The problems which exist in the application of this fluid for high-temperature service appear to be far less formidable than those presently confronting other fluids for this type of service.
5. Many of the more common materials are compatible with NaK at 540 deg. C., and will give long and satisfactory service.
6. NaK-77 is the only fluid at present available for applications where an extremely wide operating temperature range (–12 to 760 deg. C.) and long operational life are of paramount importance.

SELECTING SPRING FASTENERS

This article is by members of two leading companies in the fastener industry. The advanced design of modern spring-steel fasteners often enables one single part to be used where several were previously necessary

by R. H. EXTON* and G. MARDEN†

OVER twenty years ago a start was made in this country by Simmonds Aerocessories Ltd. on fasteners constructed principally from spring steel to replace more costly turned parts. As a result a new industry has now been created, and today every manufacturer of mass-produced components and units is alive to the substantial labour and cost saving possible by the use of special fasteners. In many cases these fasteners are so designed that one part can replace three or four parts involved with more old-fashioned methods. In order to obtain the best results from these specialised fasteners, it is necessary for the application to be considered at an early stage of design, and consultation between the designer and supplier undertaken.

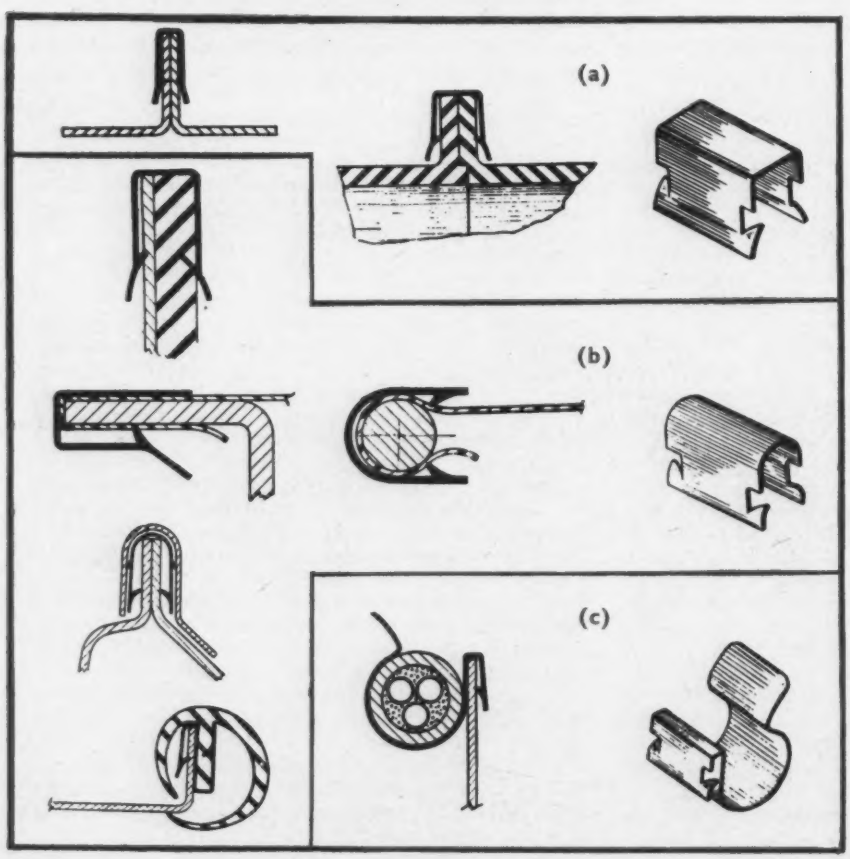


Fig. 1. Part of a range of edge-fixing clips made by F.T. Products Ltd. The fasteners shown diagrammatically in the centre column are illustrated in perspective on the right.

*F.T. Products Ltd.
†Simmonds Aerocessories Ltd.

F.T. Products Ltd.

One particular type of fixing in which F.T. Products specialise is that of edge fixing clips—a range of these is illustrated in Fig. 1; their unique feature is specially shaped prongs which give a positive grip when the parts are clipped into position by finger pressure. The wide application of this type of fixing is clearly shown, and securing pipes or wiring to a flange (c) is an obvious cost saving example. Metal capping or beading, trim material or rubber, may be secured to a metal flange or wire (b) by another shape of clip. Plastics and metal flanges may be quickly joined together as shown at (a) and in all cases the cost saving compared to screwing or riveting is appreciable. There are no less than about 150 variations of this particular type of clip alone, and new applications are being continually discovered, as well as more variations. The motor vehicle industry has been using this technique for many years, but it is apparent that as other designers and production engineers become aware of the possibilities, the same principle will have a wide scope in the majority of mass produced units.

Another example of the prong fixing principle is a clip suitable for attaching fabric and other sheet materials to tube as in car seats. This principle is now being applied to furniture of tubular construction. Fig. 2 shows the method of application; sizes are available for tubes $\frac{1}{4}$ to $1\frac{1}{4}$ in. dia.

At one time, refrigerators, washing machines, cookers, etc., were purely functional but latterly they have been carefully styled to give "eye appeal", and not only for the export markets. Decorative beadings are frequently employed, and it is desirable that these be assembled towards the end of the production line. It is therefore necessary for the beading to be attached when there is access only to the outside of the cabinet. This can be readily achieved by attaching suitable clips with blind rivets, the clips being so formed that the beading can be snapped over (see Fig. 3). If required, the clip may be provided with sprags to hold the beading from lateral movement. Such a fixing is proof against moisture and dust. If a complete seal is not essential, then a retainer and spring (see Fig. 4) may be used, the retainer being designed to suit the cross section of the beading so that it can be readily slid along and lined up with the mounting holes.

If access to the back of a panel is readily available, such as on perambulators, then the tag type (see Fig. 5) can be utilised, the specially shaped tags being turned over behind the panel. These are so designed that they assist in pulling the beading up tightly, thus eliminating rattle.

A clip which permits the attachment of rolled section beadings to wood is also available (see Fig. 6), and is of particular interest to the furniture and radio cabinet industries. These clips are installed in the beading, lined up with the drilled holes in the wood, and merely pushed home by thumb pressure to complete the assembly.

For the blind assembly of plastics or die-cast medallions, emblems or letters, there is a wide range of friction bushes which can be clipped to a metal or wood panel (see Fig. 7). The component, being fitted with integral studs, is then pushed home to be securely held. Where the component is fairly large and requires two or more studs, there is available a special design of friction bush (see Fig. 8) which does not call for any great degree of accuracy in the pitch of studs in relation to the mounting holes.

A method which is quicker than riveting or screwing, is the attachment of rubber or plastics to sheet metal by a simple spring which can be snapped home by finger pressure. A typical example is illustrated in Fig. 9—this is a very handy method of fixing. The characteristics of this fixing can be widely varied to suit the application. Production has recently commenced of a new type of clip of this shape which vir-

Fig. 2. Fabric to tube.

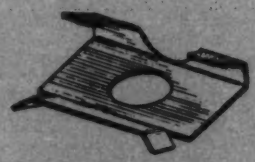


Fig. 3. Beading to panel.

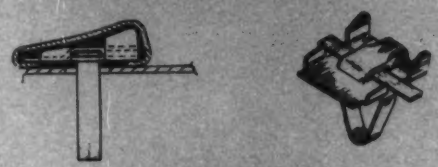


Fig. 4. Beading to panel.

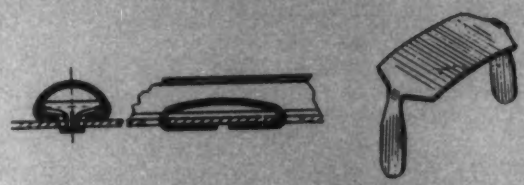


Fig. 5. Beading to panel.

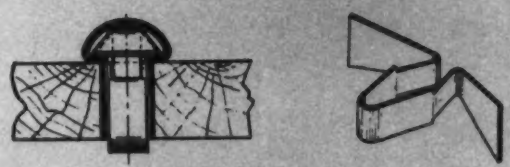


Fig. 6. Beading to wood/plastics.

Fig. 7. Stud to wood/plastics.

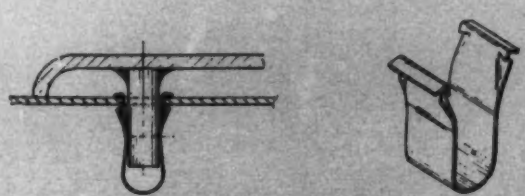


Fig. 8. Stud to panel.

Fig. 9. Rubber to metal.

Fig. 10. Lever to rod.

Fig. 11. U-clip for pivot.

Fig. 12. Pipe to panel.

Fig. 13. Fixed knob to shaft.

Fig. 14. Removable knob to shaft.

Fig. 15. Stubber to ashtray.

tually acts as a spring nail. This is tapped home by light hammering and gives a fixing strength comparable to that achieved by a screw or rivet, but can also be assembled in a fraction of the time.

In fixing a lever to a rod, a brazed washer is often necessary to space the lever from the radius of the rod, the lever itself being retained by a coil spring and split pin. The drilling of the rod for the split pin is often a costly and awkward operation. The whole assembly, with a better retention and control of the lever, can now be achieved by a single clip which is readily applied over the rod end and clipped into position. There are several different designs to meet various assembly requirements, but the one illustrated in Fig. 10 is typical, and is produced to cater for rods of $\frac{1}{4}$ to $\frac{3}{4}$ in. dia.

To assemble two flat levers, pivoting in relation to each other, a simple U-clip can be employed (as illustrated in Fig. 11). The mounting hole in one lever is plunged to register with a clearance hole in the other, and the clip completes the assembly in a simple and economical manner. Alternatively, a nylon washer with suitable pips on each side can be mated with the mounting holes in the levers. Such a design is very suitable for linkages on toys and similar simple mechanical devices.

Another new clip is designed to trap the coiled wire sheath of a remote control wire. The clip is self-retaining with respect to the panel, and the coil wire is pushed by hand into a specially shaped jaw which at once anchors it against withdrawal. In replacing a welded or screw bracket and turned unions, this clip can save time and money.

Where pipe or wiring is to be installed, there is available a simple and inexpensive type of clip which is very economical in mounting space, and which requires no more superficial area than the pipe or wiring itself. A typical application of this type of clip is illustrated in Fig. 12—this clip is produced in a number of standard sizes.

Plastics

Plastics materials offer a most interesting medium for the employment of clips with cost advantage, as very often inserts, tapped holes or riveting methods can be eliminated. For instance, plastics ball ends can be secured with a spring clip as shown in Fig. 13, provision being made in the plastics component for a simple plain socket.

Control knobs which have to be removed for service reasons can be secured by a clip which requires a very simple mounting socket to reasonable production tolerances. This is available in three variations, giving a "pull-off" of 18-20, 12-13 or 9-10 lb. respectively. It is suitable for square or D-shaped spindles or for those with a double flat—moulding details are supplied to suit the spindle condition. Compact in size, this clip employs a relatively extensive operational length of spring (see Fig. 14), and is therefore not prone to fatigue in the course of service, a torque-resisting device being incorporated in the moulding arrangement.

Another interesting principle is employed in a clip which is self anchoring in a plastics pocket, and which can be either positively locked, or removed by a firm pull if its duty should so demand. Fig. 15 shows its application to a cigarette stubber in the ashtray of a motor vehicle, but the same method can obviously be used to advantage in many other applications.

For injection-moulded cabinets or housings, where it is undesirable to have any appreciable increase in the nominal wall thickness, a spring clip has been developed which requires only a groove for mounting. The spring is pushed into its mounting and self locked against withdrawal by spring prongs biting into the plastics material. This is also a principle with general possibilities — if the plastics engaging portion of the clip is made double ended, then two pieces of plastic material can be butt joined.

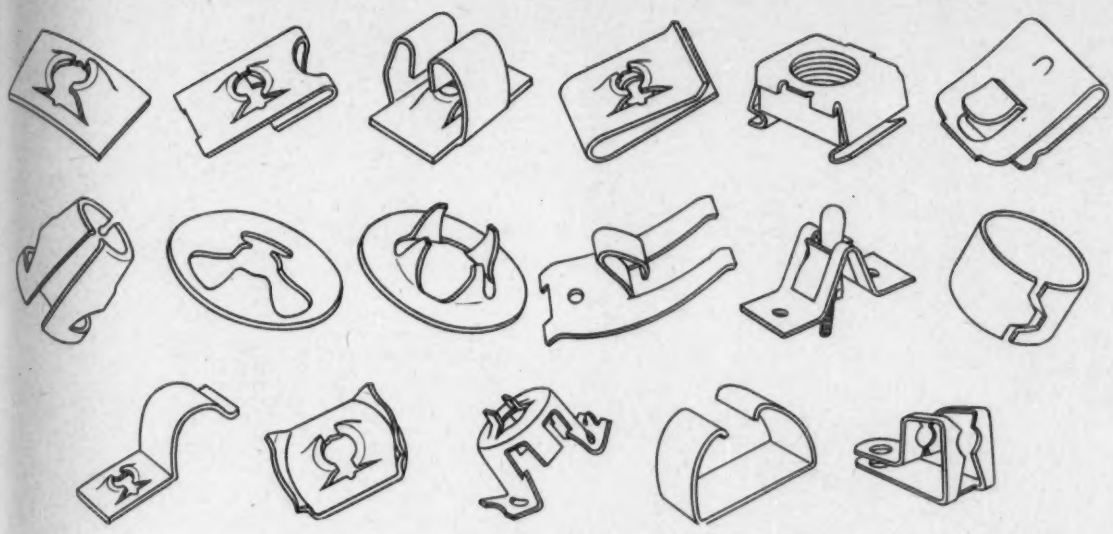


Fig. 16. Representative selection of Simmonds spring-steel fasteners.

Simmonds Aerocessories Ltd.

Spire speed nuts and spring steel fasteners made by Simmonds Aerocessories are used extensively in the mass-producing industries throughout the world, and provide a simple but highly efficient method of fastening. Their use is capable of providing enormous savings in labour costs, by reducing the number of parts handled, eliminating moulding operations, overcoming blind assembly problems, minimising material handling, and providing "float" to speed up assembly. They save considerably on material costs, and can be fitted by unskilled operators at any convenient point on the production line. Moreover, they are lighter in most cases than the parts they replace, and very much cheaper.

The Spire nuts shown in Fig. 17 consist of heat-treated spring steel pressings providing a screw thread form, or alternative method of fixing, affording a fast and effectively assembled vibration-proof lock. They can be supplied in a range of protective finishes which include zinc and cadmium plating, and zinc chromate paint. Where conditions require, they are also made in stainless steel, nickel silver and mild steel.

Unlike threaded nuts, Spire nuts do not have to be tightened with any great amount of torque. Their holding power and vibration resistance are dependent on spring tension, and they are tightened only enough to produce the thread and spring lock. The installation torque required ranges from 2 lb. in. for a 6BA machine screw, to 75 lb. in.

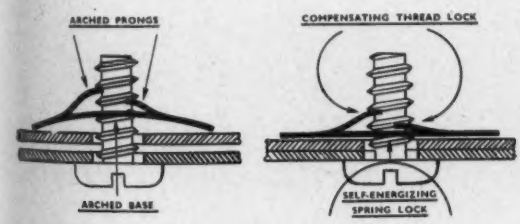


Fig. 17. Typical application of a Spire fastener *(left)* before tightening, and *(right)* after tightening.

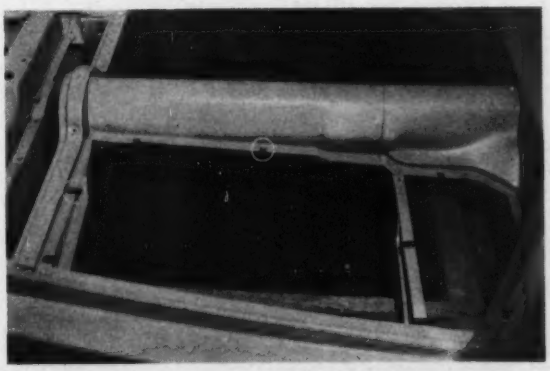


Fig. 18. SNU and SNJ nuts for blind assembly locations, shown on a car chassis.

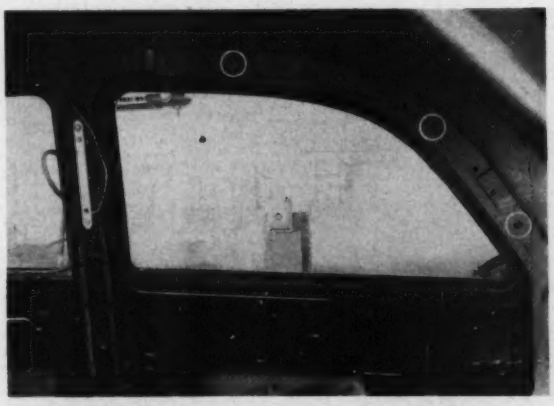


Fig. 19. Captive expansion nut used for securing trim at points remote from the panel edge.

Fig. 20. Spire nut grips used as a replacement for welded nut retainers.

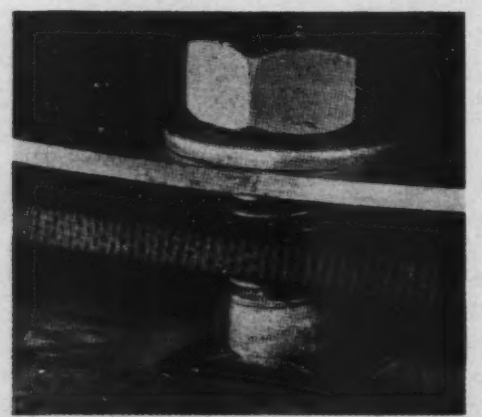
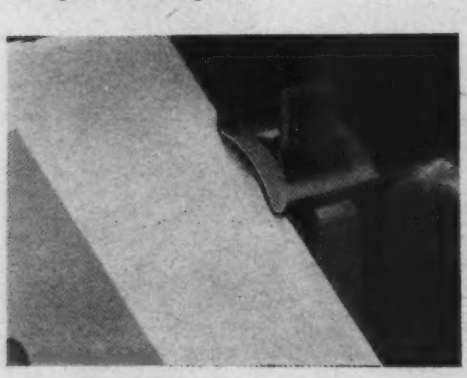


Fig. 21. Two examples of a Spire push-on fix: *(above)* for securing a bolt shank prior to assembly, and *(below)* for holding a radio tuning scale.



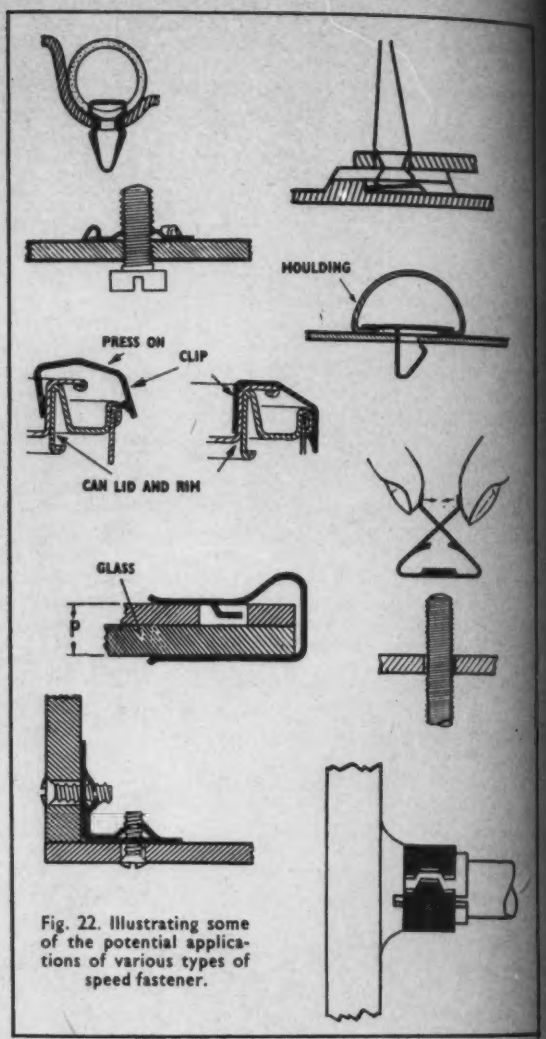


Fig. 22. Illustrating some of the potential applications of various types of speed fastener.

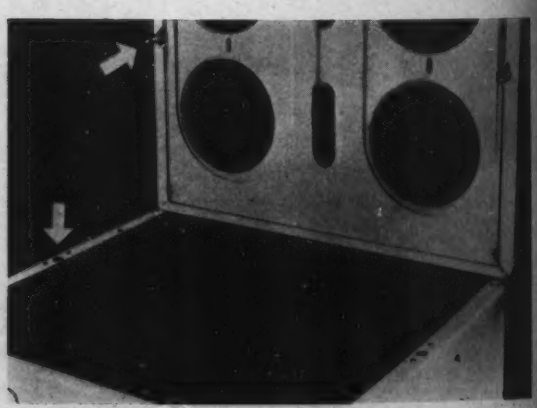


Fig. 23. Push-on fastener as applied to the lid of a cooker.

for a ¼-in. Acme bolt. Assembly is further speeded up by the use of Spire nuts with coarse threaded sheet metal screw forms, which require fewer turns of the screw to achieve locking. The ultimate tensile loadings compare very favourably with normal nuts and bolts, ranging from 2,000 lb. for the ¼-in. Acme thread types, to 340 lb. for No. 6 sheet metal screw threads.

Blind Assembly

Self-retaining fasteners such as the U-type nuts, J-type nuts, latching nuts and clips, cage nuts, expansion nuts, etc., can be snapped into position by hand either before or after painting at any convenient point in the production sequence. No re-tapping is necessary after painting. These nuts also provide a degree of "float" to allow for any misalignment of holes, thereby overcoming one of the main problems associated with mass assembly.

Captive nuts of the U and J types (see Fig. 18) are snapped over the edge of sheet metal panels—a locating tongue holds them in place over the screw clearance hole in the panel. These can be fitted at any convenient point on the assembly lines. They can also be fitted anywhere on a sheet metal panel having a suitable slot to receive them.

The expansion nut (see Fig. 19) is another type of captive nut suitable for blind assembly. These are snapped into a hole in a sheet metal panel, and replace special welded nut cages. They therefore eliminate the expense of welding operations and side-tracking of components.

The Spire cage nut provides an alternative to the expansion nut where a full threaded nut is required and consists of a cage of spring steel holding a square threaded nut. Like the expansion nut, this part is snapped into a hole in the panel at any convenient point in the production sequence after painting and enamelling. Thus the inherent difficulty of paint clogging in the thread is overcome, and the necessity of re-tapping obviated.

Other parts with thread impressions to overcome blind assembly problems include latching nuts, angle nuts and many special-purpose nuts (such as terminal nuts, wood anchor nuts, expansion nuts for cored holes in castings, and quick-release nuts).

Retainers, Clips and Other Types

There are over 600 different Spire speed fastenings. In addition to sheet metal assembly, they may be used to fasten badges and escutcheons, knobs to shafts, mouldings and trim to appliances and motor cars, refrigerator breaker strip assemblies, radio chassis components (such as coil former supports and can clips), and in many more applications.

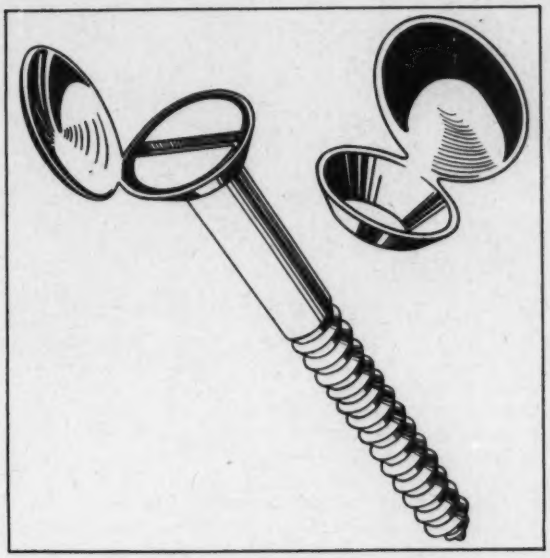


Fig. 24. Anodised or plastics-coated aluminium cap for screw.

Spring latches are particularly useful for catching lids, doors, panels, etc., where they must be readily removable. They can be supplied to suit various pull-off requirements, varying from 5-14 lb.

Push-on Fix

The Spire push-on fix (see Fig. 21) provides a permanent and economical fastening using a plain unthreaded stud. The fix is pushed down over the stud, locking the parts under firm spring tension.

Building Industry

Increasing applications are being found for Spire fasteners in the building industry, where they are used for holding suspended ceiling tiles, fastening insulation materials, partitioning and for making heating and ventilating assemblies.

Spire speed screws are supplied for use with fasteners incorporating a sheet metal screw thread. They can be obtained with various heads, either Phillips or slotted types. In addition the Simmonds Spire cap, which is an anodised or plastics coated aluminium cap for screw heads, is ideal for matching or contrasting with existing trim.

LETTERS TO THE EDITOR

Sir,

Relative to our Instantair Couplings mentioned on page 590 of your September 1961 issue, we have to advise you that the information contained therein is not correct. You have quoted the maximum pressure as being 90 p.s.i., but these couplings are suitable for a maximum working pressure of 200 p.s.i., and as non-standard couplings they can be arranged for very much higher pressures.

As given in the National Physical Laboratory report on these couplings, a pressure of 10,000 p.s.i. is obtainable without leakage. The maximum temperature shown in your item is about correct.

B.E.N. Patents Ltd. **M. H. Madkins**

Sir,

The editorial mention given to our Ruston-Grayloc high pressure and temperature pipe connection on page 589 of your September 1961 issue is misleading. Maximum working pressure and temperature are related to size, and vary from 11,000 p.s.i. for a 1-in. coupling to 634 p.s.i. for a 30-in. coupling. These ratings refer to R-G connections in standard materials suitable for welding to carbon steel pipe, and for operation up to 510 deg.C. Connections are also available in low and high alloy steels for extreme operating temperatures and corrosive conditions.

Ruston & Hornsby Ltd. **L. Blight**

Sir,

Since it is made to appear in your Survey of Pipe Couplings (page 668, October 1961) that we only manufacture bellows suitable for vacuum applications, we would like to point out that we can also manufacture a bellows suitable for working pressures ranging from 10^{-6} vacuum to 3,000 p.s.i.

J. D. Jopling
Teddington Aircraft Controls Ltd.

We regret any embarrassment caused to these three companies, but in all our surveys every precaution is taken to ensure that copy is correct by sending proofs to the firms concerned.

Soldered assembly of copper tube to brass plate. Failure occurred after 500 hr. in a proprietary cleaner at 2½% concentration.

CORROSION OF SOFT SOLDER BY DETERGENTS

THE advent of synthetic detergents has brought many advantages but also certain difficulties, the most obvious of which is the persistent foam problem at sewage works and on river weirs. A less well-known but more insidious property of many of these surface-active materials is a corrosive attack on soft-solder. Such attack is rather surprising, since tin-lead solder behaves generally as quite a "noble" metal and is relatively little affected by aqueous solutions unless chemicals such as nitrites are present.

Failure of soldered joints has occurred in washing machines and in automobile windscreen-washer pumps. One might expect to meet this effect in domestic or laundry plumbing systems, but modern design employing plastics and copper piping make it increasingly unlikely. The use of detergents in cleaning the cooling system of motor vehicles does not seem to have caused any notorious trouble due to solder corrosion, due perhaps to brief contact.

The class of surface-active agent giving rise to solder corrosion derives from the sulphonic acids. These sulphonic acid derivatives include many of the most effective detergents used today. Corrosion is more rapid in hot solutions, but even at ordinary temperatures there is appreciable attack. Total failure of a joint can occur in a remarkably short time with a detergent concentration of less than 2%.

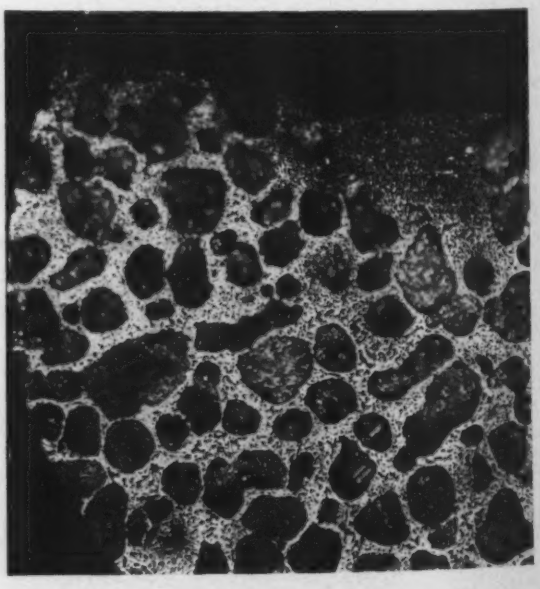
Examination of failed joints shows that tin has been selectively dissolved from the alloy; clearly this is the way in which progressive weakening of the joint takes place. The manner in which tin is dissolved is not certain, though it appears in the solution in an insoluble form. Even a lap joint with limited access of solution at an edge will fail eventually due to the penetrating powers of these active detergents. In the case of soldered joints in brass or copper there is no stifling by corrosion products as so often happens with other corrosion processes. That the corrosion in such cases may be partly electrolytic in character is shown by the behaviour of massive solder when subjected to attack. Here a form of stifling does occur, with a crust of corrosion product slowing down and finally stopping the attack. In soldered assemblies with combinations of metals in contact there is general corrosion of solder in the joint; eventual failure reveals that even the "tinning" has disappeared.

At the present time there seems to be no way of overcoming this trouble directly, and designers should avoid using soldered joints where contact with detergent solutions is likely, particularly at elevated temperature. There are cases where soldering can be avoided in a design by employing a spun-over joint. In other cases a synthetic resin adhesive might be used, or silver solder or brazing alloy if the design allows. There is only very slight attack on brass, and silver solder can be regarded as immune.

Some investigations which have a bearing on the fundamental processes involved in this type of corrosion have been carried out by Ross and other workers (see *J. Appl. Chem.*, 1960, 10 (January), 24; and *Corrosion Technology*, 1959, 6 (September), 269). There has, however, been no full explanation of the precise mechanism of this corrosion, though the broad outline given above is probably correct. We may suppose that soft solders could be developed which were not subject to this attack, though that might imply the abandonment of tin as a constituent.

With the trend towards the "soft" detergents, such as those based on polysaccharides, which are more readily broken down by bacterial action in sewage disposal, there is a chance that the incidence of this corrosion may lessen with time.

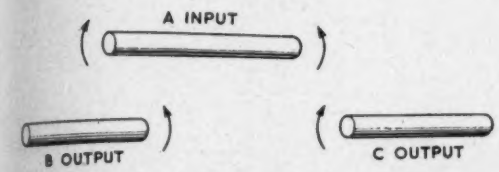
Metallographic section of corroded massive solder, etched in nitric-acetic acid/glycerol etchant. The islands are of lead in a tin-lead eutectic. Note the absence of selective attack on the tin-rich eutectic. (Magnification ×300.)



Contributed by C. Watts.

PROBLEMS IN DESIGN

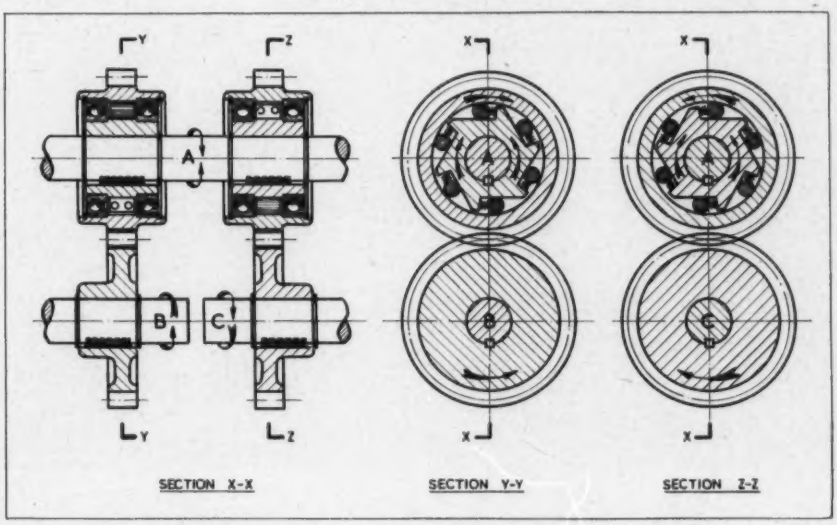
Problem No. 21 (July): Devise a mechanism which, with three shafts arranged as in the sketch, will bring about the following:



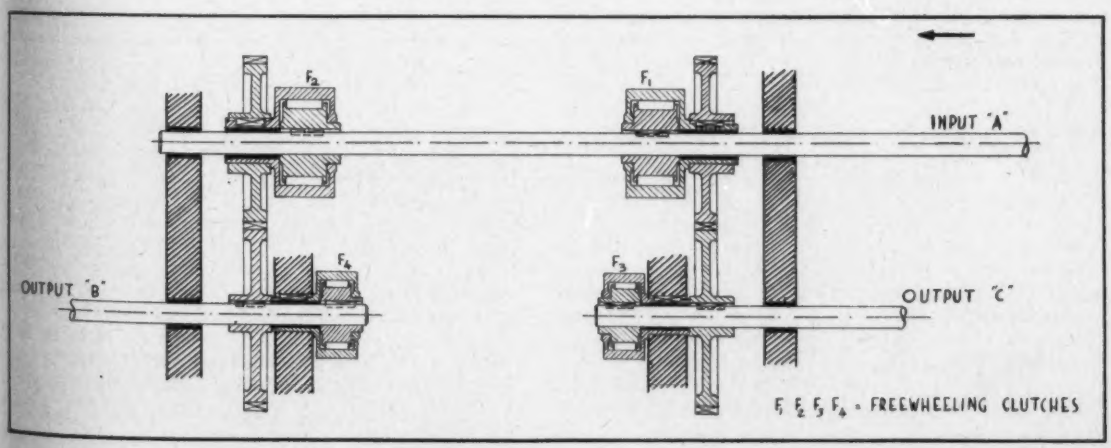
When shaft *A* revolves clockwise, shaft *B* revolves counter-clockwise and shaft *C* remains stationary. When shaft *A* revolves counter-clockwise, shaft *C* revolves clockwise and shaft *B* remains stationary.

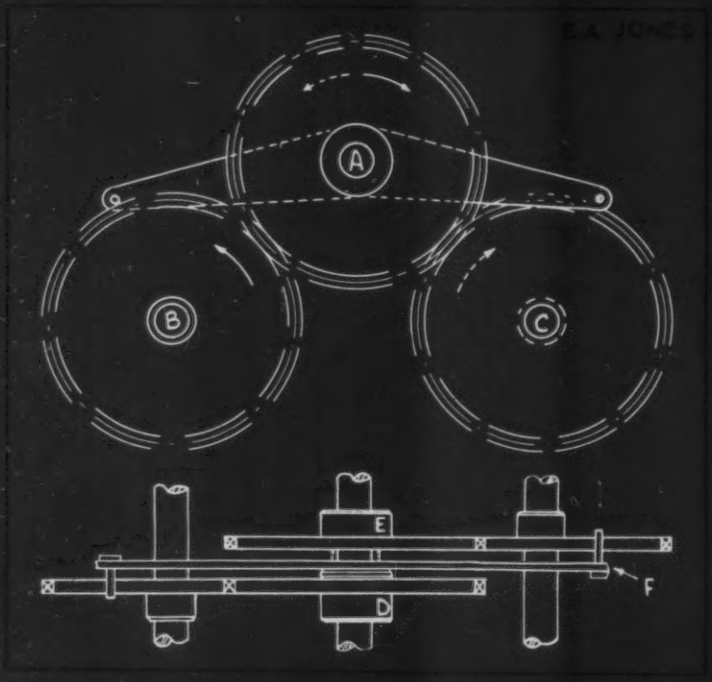
The largest number of entries to this problem incorporated freewheels such as those described in our recent survey of these devices (June and July, 1961). A good example of this type of entry is that from **J. F. Jackson** who chose a type having two integral ball bearings. Right- and left-hand units of this type are mounted at the centres of two spur gears, the inner part of each freewheel being keyed to the input shaft. Each of these spur gears engages an identical spur gear on each output shaft. This is a sound solution for cases where the resistance to torque, on the stationary output shaft, is sufficient to overcome the tendency to continue running caused by friction in the freewheel on that side. A rather more positive mechanism on the same lines, but incorporating two additional freewheels, came from **R. Stampanoni** of Johannesburg, South Africa. The two extra freewheels, mounted on the output shafts,

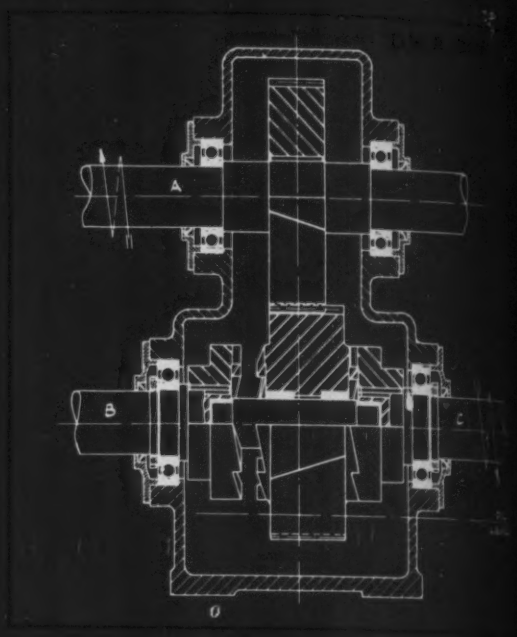
J. F. JACKSON (right)

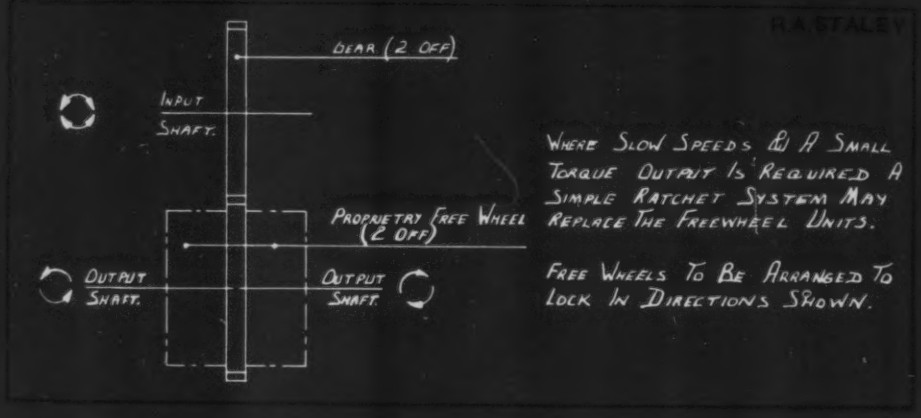


R. STAMPANONI (below)







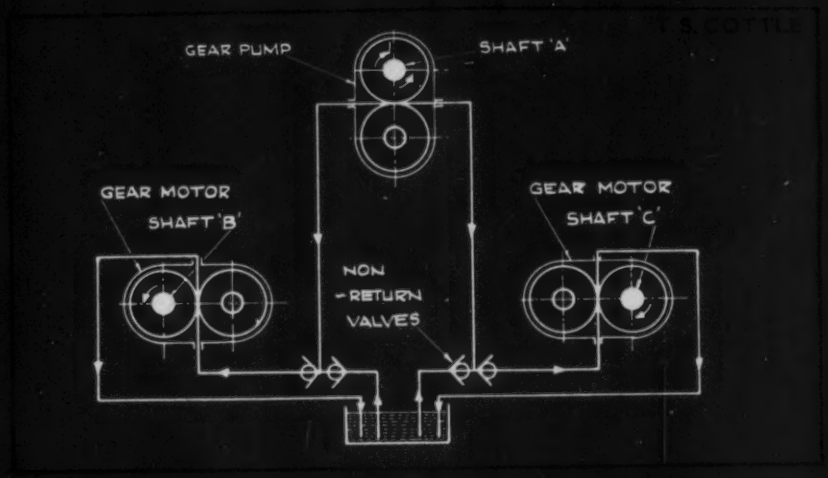

GEAR (2 OFF)
INPUT SHAFT.
PROPRIETRY FREE WHEEL (2 OFF)
OUTPUT SHAFT.
OUTPUT SHAFT.
WHERE SLOW SPEEDS & A SMALL TORQUE OUTPUT IS REQUIRED A SIMPLE RATCHET SYSTEM MAY REPLACE THE FREEWHEEL UNITS.
FREE WHEELS TO BE ARRANGED TO LOCK IN DIRECTIONS SHOWN.

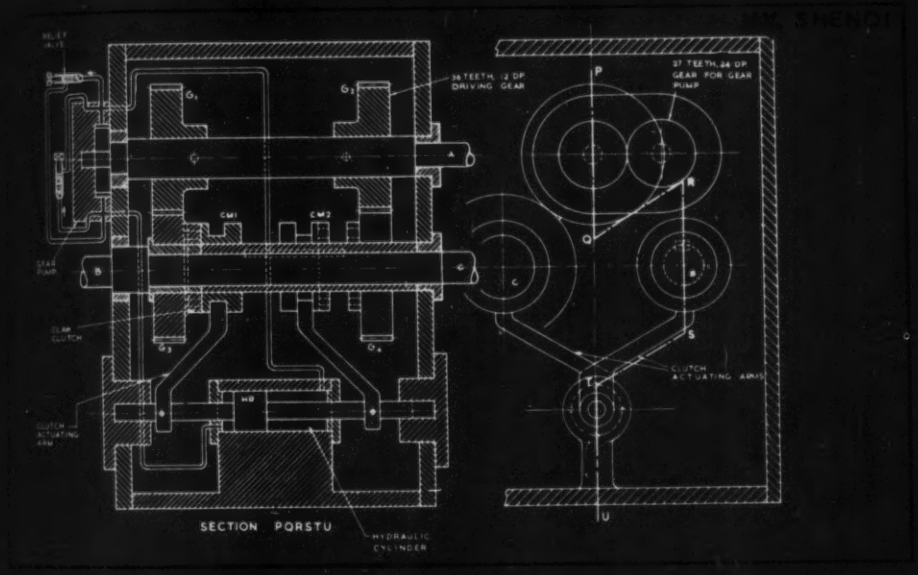
would greatly widen the number of uses to which the mechanism could be put, enabling positive indexing to be carried out. Another way of achieving the same thing, without the expense of two freewheels, came from **E. A. Jones.** He restrains the output shafts from idling by means of a friction driven lever F which carries pegs. The pegs engage in either gear, on shaft B or C, whichever is required to be stationary.

All of the entries of this sort, save that received from **R. A. Staley,** required three or four gears. He economised and used one pair only. The freewheels are mounted on the output shafts. It was not stated in the problem how far apart the shafts were to be positioned and, perhaps for this reason, **T. S. Cottle's** entry caters for cases where the shafts are widely spaced. The hydrostatic transmission he proposes consists of a fixed delivery gear pump driven by shaft *A* and two fixed displacement gear motors driving shafts *B* and *C* respectively. When *A* rotates clockwise the pump draws fluid up the right-hand line and drives shaft *B* counterclockwise. When *A* rotates counterclockwise the pump draws its fluid from the left hand pipeline and drives the right hand pump, thus causing *C* to rotate clockwise. The non-return valves ensure that the hydraulic fluid follows the correct route. Although there would be some degree of slip with such a drive it is a possible, though costly, solution.

Another entry involving hydraulics is that from **N. V. Shenoi** of Bangalore, India. His input shaft, carrying two spur gears, drives a two-way gear pump which supplies a hydraulic actuator. According to the direction of rotation of the input shaft, oil is supplied to the right- or left-hand side of the cylinder, and the ram engages the left- or right-hand spur gear on the output shaft and withdraws the opposite gear from engagement. We consider this to be a novel but rather fussy solution. Mr. Shenoi sent another entry which was of the simpler gear and freewheel type.

Lastly we include an ingenious entry from **D. W. R. Couvacic,** who uses the combined axial thrust of two single helical gears to cause the output gear to move to right or left, according to direction of rotation, and so bring about the engagement of dog clutches.

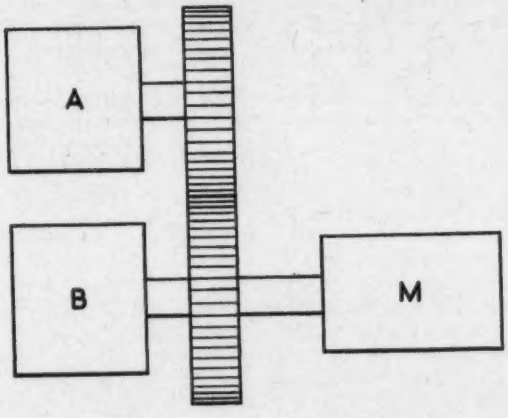




PROBLEM IN DESIGN No. 25
Here is this month's problem

Geared motor *M* operates two rotary devices *A* and *B* which are geared together by 1:1 gears. The motor output is limited (by means not shown) to a range of 5 revolutions. Each device is able to rotate also through 5 revolutions. When the devices *A* and *B* are geared to work in the same phase, the motor, *A* and *B* all do 5 revolutions, *A* and *B* both covering their full range. The gears can be slipped out of mesh, and *A* can be rotated up to 2 revolutions out of phase with *B* in either direction and the gears then re-engaged.

The requirement of the problem is that when one of the devices comes to the end of its travel, the other can continue to operate after the first has stopped by anything up to 2 revolutions, but when the mechanism is reversed the drive to the first must be picked up in the preset phase.



Best solutions to "Problems in Design" are published and paid for Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12 × 12 in., please!) to the Edi tor "Problems in Design No. 25 (November)". Closing date December 20.

MATERIALS SELECTION IN DESIGN

The author discusses a new approach to the presentation of data on the properties of engineering materials. Typical examples of his simplified "selection charts" are set out on the last three pages of the article

by J. S. SHAPIRO, Dipl.Ing., A.M.I.Mech.E., A.F.R.Ae.S.,
and W. S. MAIDMENT, A.M.I.Mech.E., A.F.R.Ae.S.

ENGINEERING designers invariably find themselves both chasing information and devising means of coping with an excess of it. This situation is fundamentally unavoidable, and can be met only by better efficiency of chasing and better methods of screening.

In this article the author is concerned with information about materials used in engineering. Information on these materials is available in a bewildering profusion. Quantity is not the only problem. Within the mass of information easily accessible, and especially in the constant flow of new information, there is a heavy bias in favour of a minority. Periodical literature tends to favour the glamour of peak achievements and frontline problems which are the province of very few designers.

This bias is not justified even by its value as setting a good example. Unlike model garments, the excellent properties of a new platinum alloy cannot be brought out in a cheap edition. The failure to appreciate the latest developments in super-heat-resisting alloys is probably not even fractionally as harmful economically as perhaps the failure to realise that a carbon steel is as good as alloy steel in certain applications.

An equally common but more justified bias of information about materials is the concentration on variants significant only in mass production. It is certainly good practice to devise a material specification having a combination of properties valuable only in, say, motor-car valve springs and nowhere else.

This brings us to the central point of the present contribution to the selection method of materials for engineering designers. Although there are millions of valve springs made every year, it is doubtful whether more than ten people in this country are concerned with their design. There are probably about 20,000 people concerned occasionally with the design of springs, none of which would be a valve spring for motor car engines.

Is it really necessary that all the 20,000 should have to wade through a list of specifications containing special valve spring materials? The answer to this rhetorical question is obvious. So long as we think of any one unnecessary entry in the list, we can dismiss it as nothing more than a nuisance. However, the case of the valve spring is multiplied several hundreds of times.

On this scale, the problem ceases to be a mere nuisance —or even one of efficiency of design work alone—it becomes a problem of principle. The human brain in its active condition cannot hold hundreds and thousands of useless items of information—the problem demands another and easier solution.

There are two main solutions at each end of the scale of engineering design work. At one end of the scale a large design office would have a materials and methods engineer who would either propose the initial selection of material or check the designer's proposal. At the other end of the scale, a very primitive design office would give up all refinements and confine itself to such simple selection as "steel", "brass" or "cast iron".

A practical aid to the selection of material is proposed here which avoids both extremes. Such an aid must be managable in the hands of the smallest design office, and yet sufficiently refined to avoid grossly uneconomic design.

Ideally, every office ought to have its own range of selection, but in practice a large majority of engineering design is concerned with a variety of products which are manufactured from similar ranges of materials and produced in roughly the same quantity, so that its needs can be covered by the same range and refinement of selection. Neither too much information nor too little is the principle underlying the proposed selection charts, which have developed in the actual practice of material selection in a small but highly qualified design office with a variety of interests. These charts are reproduced here for the benefit of the many engineering designers faced with the same problem.

Naturally, in publishing the selection charts the need arose to fill up many gaps which were left by the natural process of hammering out the essentials of information on materials in the practical experience of a single office. Such gaps were filled in with the same outlook, although they lack the sanction of practice. For this reason, some corners of the charts now offered are more tentative than others. At certain points criticism may be justified and a revision of the charts necessary.

The uninitiated may ask themselves why this pruning of the multitude of materials specifications has not been done by authorised organisations specifically concerned

with materials. The author believes the answer lies in the fact that such organisations represent those who are in business to make and sell materials. Since every selection includes discrimination, it is within the terms of reference of material manufacturers' organisations to discriminate on a different basis.

Insofar as some discrimination is inevitable in any form of standardisation, the guidance for such discrimination which must prevail when the entire field of engineering materials is concerned cannot be the same as the guidance used here, which is *design orientated*, and which specifically excludes (a) specialised applications, and (b) applications wherein the quantity justifies the highest refinement of selection.

In judging the charts so presented these principles should be firmly borne in mind. Only by the exclusion of the two large classes (a) and (b) are the charts possible and justified. Thus, the suggestions here are not to be understood as a criticism of standardisation practice for industry as a whole, even though this practice may itself not be above criticism.

The design orientation of the charts is not to be understood as being dictated merely by the shortness of the memory of the designer on the drawing board. The engineering designer is here conceived as the design engineer concerned with the creation and development of a product. The selection was therefore so made that such points as variety of internal stockholding, availability with general stockists, and cost have been taken into account. The charts themselves are constructed in a manner which underlines these considerations as well as certain manufacturing features as, for instance, the separate listing of free machining bar and the almost overriding importance of weldability.

At the same time, in conformity with the general principles adopted for this particular selection method, manufacturing processes suitable only for mass production have been left out altogether on the grounds that, if the quantity justifies mass production, it equally justifies the materials and methods engineer who has the experience, knowledge and facilities to use the entire field of materials offered by materials manufacturers. The following list shows some of the manufacturers, suppliers and stockists of the materials mentioned in this article. The list is not intended to be exhaustive, and does not necessarily represent the full activities of the company concerned. It will however serve as a guide to the supply of materials in a specific group.

LIST OF MANUFACTURERS, SUPPLIERS AND STOCKISTS

FERROUS METALS:

Ayrshire Metal Products Ltd.	Formed sections.
David Brown Corp. (Sales) Ltd.	Steel castings.
Curran Steels Ltd.	Steel castings.
Colvilles Ltd.	Bar, plate and sheet.
Darwins Ltd.	Castings.
Daniel Doncaster & Sons Ltd.	Forgings.
Davy & United Roll Foundry Ltd.	Steel castings.
Ductile Steels Ltd.	Steels.
English Steel Rolling Mills Corp. Ltd.	Steels.
Edgar Allen & Co. Ltd.	Steels.
Forgings & Presswork Ltd.	Cold extrusions.
Firth Derihan Stampings Ltd.	Forgings.
Firth Vickers Stainless Steels Ltd.	Cast and wrought forms.
John Fowler & Co. (Leeds) Ltd.	Castings.
John Harper & Co. Ltd.	Cast irons.
J. A. Hemming Ltd.	Bright steel strip.
Head Wrightson Stamping Ltd.	Drop forgings.
International Meehanite Metal Co. Ltd.	Cast irons.
The International Nickel Co. (Mond) Ltd.	Nickel steel and iron alloys.
Jessop-Saville Ltd.	High-temperature steels
Kayser Ellison & Co. Ltd.	Tool steels.
Keeton Sons & Co. Ltd.	Bored bars.
Kirkstall Forge Engineering Ltd.	Bright steel bars.
Kent Alloys Ltd.	Cast iron.
Lake & Elliot Ltd.	Iron and steel castings.
Arthur Lee & Sons Ltd.	Stainless steel strip.
William Lee & Sons	Malleable iron castings.
Midland & Lowmoor Iron & Steel Co. Ltd.	Magnetic irons.
Macready's Metal Co. Ltd.	Bright steel bars.
Samuel Osborn & Co. Ltd.	Precision steel castings.
F. Parramore & Sons (1924) Ltd.	Iron castings.
P. I. Castings (Altrincham) Ltd.	Precision steel castings.
Reynolds Tube Co. Ltd.	Hollow extrusions and tubes in steel, light alloy and brass.
S. Russell & Sons Ltd.	Iron castings.
The Rapp Group of Companies	Steel and light alloy stockists.
Sheepbridge Alloy Casting Ltd.	Corrosion- and heat-resisting castings.
J. Smith & Sons (Clerkenwell) Ltd.	Nickel silver, brass, copper and light alloy stockists.
Alfred Steel & Sons Ltd.	Steel castings
Spear & Jackson Ltd.	Tool steels.
Sheepbridge Alloy Castings Ltd.	Iron and steel castings.
The Steel Company of Wales Ltd.	Steel sheet.
Sanderson Brothers & Newbould Ltd.	Tool steels.
Walter Somers Ltd.	Die steel.
Spencer Wire	Bright Steel
Stewart & Lloyds Ltd.	Tubes.
John Thompson & Castings Ltd.	Iron castings.
Workington Iron & Steel Co.	Steel bars.
Henry Wiggin & Co. Ltd.	Nickel alloys.

LIGHT ALLOYS:

Brass and Alloy Pressings Ltd.	Pressings.
British Aluminium Co. Ltd.	Sheet, bar and plate.
Birmetals Ltd.	Aluminium sheet, strip, plate extrusions, tubes and forgings.
Blackwells Metallurgical Works Ltd.	Extrusion and forging stock, bar and wrought magnesium alloys.
City Casting & Metal Co. Ltd.	Non-ferrous ingots.
Ellay Tubes Ltd.	Non-ferrous tubes.
J. Frankel (Aluminium) Ltd.	Aluminium alloys.
Fry's Die Castings Ltd.	Die castings.
High Duty Alloys Ltd.	Sheet plate, strip, tubes, bars, extrusions and forging stock.
Imperial Aluminium Co. Ltd.	Sheet, plate, strip, tube, wire, bars, extrusions and forging stock.
Kent Alloys Ltd.	Castings.
Magnesium Elektron Ltd.	Magnesium castings and wrought forms.
T. J. Priestman Ltd.	Aluminium alloy ingots.
Reynolds Tube Co. Ltd.	Hollow extrusions and tubes in brass, aluminium alloys and steel.
The Rapp Group of Companies	Light alloy and steel stockists.
Southern Forge Ltd.	Aluminium alloy extrusions, tubes and forgings.
Sterling Metals Ltd.	Light alloy castings.
J. Smith & Sons (Clerkenwell) Ltd.	Aluminium and bronze stockists.
J. Stone & Co. (Charlton) Ltd.	Light alloy castings.

BRONZES:

Brass & Alloy Pressings Ltd.	Pressings.
Thomas Bolton & Sons Ltd.	Bars, sheet, drawn and rolled sections, tubes and bolts.
The Eyre Smelting Co. Ltd.	Bars and rods.
John Holdroyd & Co. Ltd.	Castings.
The Hoyt Metal Co. of Gt. Britain Ltd.	Ingot and bar.
I.C.I. Ltd.	Rod, bar and sheet.
Kent Alloys Ltd.	Castings.
Manganese Bronze & Brass Co. Ltd.	Bars and tubes.
Platt Metals Ltd.	Ingots
J. Stone & Co. (Charlton) Ltd.	Castings.

STEEL — General Engineering Specifications

Stock	Choice	20–30 t.s.i.				30–45 t.s.i.				45–60 t.s.i.				over 60 t.s.i.			
		Stainless		Non-stainless		Stainless		Non-stainless		Stainless		Non-stainless		Stainless		Non-stainless	
		Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld
Free M/c Bar	1	—	—	EN1A	—	—	EN56AM	—	EN8M	—	EN56BM	—	—	—	—	—	—
	2	—	—	EN1B	—	—	EN58	—	—	—	—	—	—	—	—	—	—
General Bar	1	—	—	EN3B	—	EN58A	EN56A	EN14	EN8	—	EN57	—	EN16T	—	—	—	EN16U
	2	—	—	—	—	EN58B	EN56B	—	EN6	—	—	—	EN24T	—	—	—	EN24U
Case Hdn. Bar	C	—	—	EN32	—	—	—	EN34	—	—	—	EN36	—	—	—	EN35	—
	N	—	—	—	—	—	—	EN40A	—	—	—	EN40B	—	—	—	—	—
Forgings and Stampg's	1	—	—	EN3A	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wire	1	—	—	BS1052 soft	—	—	—	—	BS1052 hard	—	—	—	EN49A‡	—	EN58A	—	EN490‡
	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	EN49D‡
Plate	1	—	—	BS15	—	EN58B	—	—	—	—	—	—	—	—	—	—	—
	2	—	—	—	—	EN58J	—	—	—	—	—	—	—	—	—	—	—
Sheet	1	EN56A	—	EN2	—	EN58B	—	—	EN5	—	—	—	—	—	—	—	—
	2	—	—	EN2C	—	EN58J	—	—	—	—	—	—	—	—	—	—	—
Strip	1	EN56A	—	EN2	—	EN58B	—	—	—	—	—	—	—	—	—	—	EN42
	2	—	—	EN12C	—	EN58J	—	—	—	—	—	—	—	—	—	—	—
Tube: Hot-rolled		—	—	BS806	—	—	—	—	—	—	—	—	—	—	—	—	—
Cold-drawn		—	—	BS908 CDS2	—	—	—	—	—	—	—	—	—	—	—	—	—
Welded		—	—	BS908 ERW1	—	—	—	—	—	—	—	—	—	—	—	—	—
Welded Cold-drawn		—	—	BS908 CEW1	—	—	—	—	—	—	—	—	—	—	—	—	—

C=Carburising N=Nitrogen hardening ‡=Used for springs

STEEL — Aircraft Specifications

Stock	Choice	25–35 t.s.i.				35–45 t.s.i				45–65 t.s.i.				Over 65 t.s.i.			
		Stainless		Non-Stainless		Stainless		Non-stainless		Stainless		Non-stainless		Stainless		Non-stainless	
		Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld
Free M/c Bar	1																
	2																
General Bar	1	S110B	S110B	S21B	S1B				S92B		S80B		S96B				S97B
	2			S92B													S99B
Case Hardened	C			S14B				S15B									S82B
	N												S106				
Forging and Stamping	1	S110C	S110C	S21C							S80C		S96C				S97C
	2			S92C													S99C
Wire	1		DTD 161												DTD 326A		WI DTD 239A
	2																
Plate	1			S510				Forti-Weld									
	2																
Sheet and Strip	1	DTD 171	DTD 171	S510	S510			Forti-Weld				DTD 124	DTD 124		DTD 166		
	2	DTD 166		S84	S84												
Tinned Steel Sheet	1				S20												
	2																
Tube	1	T55	T55	T45				T59	T45			T60	T59				T60
	2			T35									T50				4T2
Casting	1												DTD 666				DTD 705
	2																

C—Carburising N—Nitrogen hardening

COPPER-BASE ALLOYS — General Engineering Specifications

Stock	Choice	Brass U.t.s. (t.s.i.) <20	Brass 20 to 30	Brass 30 to 40	Brass Over 40	Al Bronze U.t.s. (t.s.i.) <20	Al Bronze 20 to 30	Al Bronze 30 to 40	Al Bronze Over 40	Remarks (A)=Annealed (H)=Hard	Phos. Bronze U.t.s. (t.s.i.) <20	Phos. Bronze 20 to 30	Phos. Bronze 30 to 40	Phos. Bronze Over 40	Remarks (All steels are BS)
Free Machine Bar	1	—	249	—	—	—	—	—	—	249—high speed m/c	—	—	—	—	
	2	—	—	—	—	—	—	—	—		—	—	—	—	
General Bar	1	—	1949	250B	—	—	—	DTD 160	DTD 164A	DTD 160, 164 and 197 can be heat-treated	—	DTD 354	—	—	369—bearings and gears
	2	—	218	250A	—	—	—	—	DTD 197A		—	—	—	369	
Forging and Stamping	1	—	218	1001	—	—	—	DTD 160	DTD 164A		—	—	—	—	
	2	—	251	1002	—	—	—	—	DTD 197A		—	—	—	—	
Sheet	1	—	267A	—	267H	—	—	—	—	267—deep drawing	—	407/2 (A)	—	407/2 (H)	For springs
	2	—	266A	—	266H	—	1867A	—	1867H	266—cold working	—	407/1 (A)	—	407/1 (H)	
Strip	1	—	267A	—	267H	—	—	—	—		—	407/2 (A)	—	407/2 (H)	
	2	—	266A	—	266H	—	1867A	—	1867H			407/1 (A)	—	407/2 (H)	
Plate	1	—	267A	—	267H	—	—	—	—		—	—	—	—	
	2	—	266A	—	266H	—	1867A	—	1867H		—	—	—	—	
Wire	1	—	DTD 627	—	—	—	—	—	—	DTD 627—good m/c properties	—	384A	—	384H	384—Light springs
	2	—	—	—	—	—	—	—	—		—	—	—	—	
Tube	1	—	378A	378H	—	—	—	—	—	378—corrosion resistant	—	2752A	—	2752A	2752—for fuel pipes
	2	—	—	—	—	—	1867A	—	1867H						
Casting	1	1400	—	—	—	—	—	DTD 174A	DTD 412	DTD 174 and 412 are suitable for sand- and die-casting	1400	1400	—	—	PB1—for bearings
	2	B2C	—	—	—	—	—	—	—		PB3C	PB1–2C	—	—	PB2—for gears

LIGHT NON-FERROUS — Aircraft Specifications

Stock	Choice	Aluminium Alloys Less than 10 t.s.i. Weld	Less than 10 t.s.i. Non-weld	10-20 t.s.i. Weld	10-20 t.s.i. Non-weld	Over 20 t.s.i. Weld	Over 20 t.s.i. Non-weld	Magnesium Alloys Less than 8 t.s.i. Weld	Less than 8 t.s.i. Non-weld	8-15 t.s.i. Weld	8-15 t.s.i. Non-weld	Over 15 t.s.i. Weld	Over 15 t.s.i. Non-weld	Remarks
Free M/c Bar	1				Dural C								DTD 259A	Dural C is manufactured by James Booth Ltd.
	2													
General Bar	1	L34		L44			L65			DTD 5011		DTD 622A		
	2						L64			DTD 142A				
Plate	1						DTD 5010							
	2						DTD 5030							DTD 5030—clad plate.
Sheet and Strip	1	L16		L59			L72			DTD 5001		DTD 626A		L72 clad sheet—min. rad. 3t DTD 5001 and 626A—min. rad. 8t.
	2	L17		L60			L73			DTD 118A				L73 clad sheet—min. rad. 5t
Bearing Materials	1													
	2													
Tube	1	L54		L55		DTD 186	L63			DTD 5021				L54—suitable for petrol and oil.
	2			L56			L62			DTD 737				L56—suitable for petrol and oil.
Extruded Sections	1									DTD 5011		DTD 622A		
	2									DTD 142A				
Sand Castings	1	L33		L53							BS L122		DTD 721	DTD 721—high 1% proof.
	2	L51												

LIGHT NON-FERROUS — General Engineering Specifications

Stock	Choice	Aluminium Alloys						Magnesium Alloys						Remarks
		Less than 10 t.s.i.		10-20 t.s.i.		Over 20 t.s.i.		Up to 8 t.s.i.		8-15 t.s.i.		Over 15 t.s.i.		
		Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	Weld	Non-weld	
Free M/c Bar	1 2				Dural C						BS 1354			Dural C is manufactured by James Booth Ltd.
General Bar	1 2	EIC	EIC	NE4			HE14T HE15W			BS 1355				
Plate	1 2						HP15 HPC15W			BS 1353				BS 1353—min. rad. 8t. HPC15W—clad plate.
Sheet and Strip	1 2	S1C½H S1CH		NS3¾H NS3½H			HC15W HC15WP			BS 1353				HC15W—clad sheet min rad. 3t. BS 1353—min. rad. 6t. HC15WP—clad sheet min. rad. 5t.
Tube	1 2	TIC		NT4½H NT4-0		NT7				BS 1357			BS 1356	
Extruded Sections	1 2									BS 1355			BS 1354	
Die Casting	1 2	LM6-M LM23-P		LM10W										
Sand Casting	1 2	LM6-M LM23-P		LM10W							BS 1278		BS 1275	BS 1275—high 1% proof.

FERROUS CASTINGS — General Engineering Specifications

Stock	Less than 15 t.s.i.	15–20 t.s.i.	20–30 t.s.i.	30–40 t.s.i.	40–50 t.s.i.	50–60 t.s.i.	Remarks
Grey Iron	BS 1452 (grades 10 and 12)	BS 1452 (grades 14 and 17)	BS 1452 (grades 20, 23 and 26)				
Spheroidal Graphite Iron			BS 2789 (types 2A and 2B)	BS 2789 (type 1)			High impact and elongation
Malleable Iron (Blackheart)		BS 310 (grade B18/6)	BS 310 (grade B20/10/B22/14)				Relatively cheap
Carbon Steel			BS 592 (grade A)	BS 592 (grades B&C)			High impact and elongation
Alloy Steel					BS 1458	BS 1459	
Cr/Mo steel					BS 1461 BS 1462 BS 1463		Creep resistant
Ni/Cr/Mo Steel			BS 1632				
Austenitic Steel			BS 1631				Heat-and Corrosion-resistant
Cr/Ni/Steel				BS 1631 (grades: A; B (Nb); and B (Ti))			Grades B (Nb) and B (Ti) are suitable for welding without heat treatment
Carbon Steel for Surface Hardening					BS 1760 (grades A and B)		

WHO'S WHO AT THE DESIGN CONFERENCE

Here is a quick-reference guide to the speakers at the second Engineering Materials and Design Conference, which is to be held at Earl's Court from November 13 to 17, running concurrently with the Exhibition

Design Problems with Bluebird

K. W. NORRIS

went to Lewes County School and studied at the Coventry Polytechnic and subsequently at London University. In 1938 he was apprenticed to Armstrong Whitworth, later worked in the firm's stress and design office and eventually transferred to its mechanical test laboratory. Since 1952 he has been a director of Norris Brothers Ltd. He was born in 1922.

L. H. NORRIS

has, like his brother, been a director of Norris Brothers Ltd. since 1952. Educated at Lewes County School, West Ham Municipal College and Wimbledon Polytechnic, he served his apprenticeship with Harland and Wolff Ltd. From 1946 to 1948 he was a mechanical engineer on the staff of the Burma Oil Company. Then he spent four years with Kine Engineering Ltd. as works manager. He was born in 1924.

Organisation of a Materials Department

F. C. CARPENTER

is an executive with Smiths Aircraft Instruments Ltd. He was born in 1916 and took his B.Sc. degree with honours at the University College of Wales at Aberystwyth. During his subsequent career, he worked initially on the manufacture of war gases and fine chemical products, and then joined the materials research laboratory of Mullard Ltd. where he remained for ten years. In 1951 he joined Smiths Aircraft Instruments Ltd. as technical executive of the materials laboratory.

Metallurgy Applied to the Selection of Metals

D. BIRCHON

is a senior scientific officer at the Admiralty Materials Laboratory of the Royal Naval Scientific Service at Holton Heath, Dorset. After an engineering apprenticeship he gained an external B.Sc. degree at London University. Since 1945 he has been engaged upon metallurgical research work for the Admiralty. He is the author of a book dealing with Optical Microscope Technique, and of a number of scientific papers which have appeared in various technical journals.

Recent Developments in Insulating Materials

J. WAINWRIGHT

has specialised during a large part of his career in the production and development of insulating materials and techniques. After serving an engineering apprenticeship with the English Electric Co. Ltd. at Stafford, he has spent almost twenty years in the company's insulation engineering department. He is now insulation engineer at Stafford, responsible for the running of the complete department.

Adhesives for Engineering

E. J. CATCHPOLE

is manager of the bonded structures division of CIBA (A.R.L.) Ltd., where he is responsible for the development, production, technical service and sales of structural adhesives and honeycomb core. He was educated at Northampton Engineering College, London, and at Georgia Institute of Technology, U.S.A. In 1949 he joined Vickers-Armstrongs (Aircraft) Ltd. at Weybridge, where he was concerned with aerodynamics, flight testing, stressing and project stressing.

Elastomers in Engineering

D. A. SMITH and D. G. FRANKS

have both been on the full-time lecturing staff of the National College of Rubber Technology in London for more than six years.

Mr. Smith, who is 31, took his B.Sc. in special chemistry at University College, London, in 1951, and was subsequently employed by the U.K. Atomic Energy Authority at Aldermaston. He was released for a year to complete research studies at the N.C.R.T., and later returned to the A.E.A. for liaison and specification work dealing with the application of polymers in engineering.

Mr. Franks, who is 32, took his B.Sc. in special chemistry at the Northern Polytechnic in 1948 before taking up a post-graduate course at the N.C.R.T. After service in the R.A.F., he has worked on the development and manufacture of rubber products, with P. B. Cow & Co. Ltd.

Designing for Die-casting

H. K. BARTON

who contributes a paper on designing for die-casting techniques, entered the die-casting industry in the early 'thirties, and for the past twenty-one years has been engaged in private practice as a consultant. He is the author of a number of books on die-casting production and design, and has written extensively for technical journals both in Europe and in the U.S.A. In the field of die-casting production, his particular interest has been for many years focused on metal flow.

The Case for Steel Castings

F. CLYMER

has been technical director since 1958 of F. H. Lloyd & Co. Ltd. and of Lloyds (Burton) Ltd. He is thirty-eight years old, and studied at Wednesbury County, Wimbledon and Wolverhampton & Staffs. technical colleges. He joined F. H. Lloyd & Co. in 1939 and served in the engineering and methods departments of that company before being appointed a methods engineer in 1946. He subsequently held the posts of methods superintendent, process engineer and foundry manager, before becoming technical director of the two companies.

Recent Developments in Graphite

A. J. KENNEDY

has been professor in materials at the College of Aeronautics, Cranfield, since 1957, and is concerned at present with research on the high-temperature deformation characteristics of graphite. He graduated in physics at University College, London, in 1943, and after war service returned to U.C.L. to lecture in the department of physics and to carry out research on the creep of metals. He obtained a Ph.D. for this work in 1950, and then moved to the Royal Institution where he extended his studies to questions of thermally-activated recovery in metals. From 1951-54 he held the Royal Society Armourers' and Brasiers' Research Fellowship, and then moved to B.I.S.R.A. as head of the metal physics section, where he commenced his studies of behaviour of metals under combined creep and fatigue. Since 1957 he has studied the behaviour of high-strength light alloys in supersonic aircraft. In 1959 he undertook a survey of the graphite situation for the NATO aeronautical research and development advisory group.

Some Properties, Applications and Potentialities of Investment Castings

L. S. TAYLOR

was born in 1928, and was educated at Bromsgrove County High School, Worcestershire. He received his engineering training as a student engineering apprentice at the Austin Motor Co., Longbridge, where he later specialised in foundry work. He later moved to Deritend Precision Castings Ltd., subsequently becoming chief metallurgist before leaving to join G. L. Willan Ltd. He is a member of the council of B.I.C.T.A., and chairman of its metallurgy committee.

A. G. MASON

was born in Birmingham and educated at Handsworth Grammar School. He started work at Northern Aluminium Co. Ltd., in Birmingham, subsequently occupying a number of technical positions associated with laboratory and foundry development work. In 1957 he moved to Deritend Precision Castings Ltd. as chief metallurgist, and for a period of two years also held the position of chief inspector. He is a diploma holder of the National Foundry College, and a member of the metallurgy committee of B.I.C.T.A.

Steels for the Design of Low-temperature Equipment

E. T. GILL

who is now alloy steels development officer of the International Nickel Co. (Mond) Ltd., in London, has had long experience in the British steel industry, which began with service with Hadfields Ltd. in Sheffield, and Samuel Fox & Co. Ltd. at Stocksbridge. In 1936, when he was chief metallurgist of Bruntons Ltd. at Musselburgh, he was awarded a Carnegie Scholarship by the Iron and Steel Institute for the continuance of his research on the fatigue properties of patented steel wire. He spent eight years with I.C.I. Ltd. at Billingham and in Sheffield, and during the war was seconded to Firth Vickers Stainless Steels Ltd. as works manager of their M.A.P. factory at Barnsley. Since the war he has been deputy chief metallurgist with Edgar Allen & Co., and metallurgist to the Climax Molybdenum Co. of Europe Ltd. He was president of the Sheffield Metallurgical Association in 1950.

Recent Developments in Permanent Magnet Materials

J. E. GOULD

has for the past nine years been director of research to the Permanent Magnet Association, based on its central research laboratory at Sheffield. He has in fact been associated with permanent magnet manufacture and development for thirty years, initially with some of the leading manufacturing companies. He now heads the research activities of the P.M.A. which carries out all aspects of research into permanent magnet materials and is recognised as a leading authority on the subject.

Plastics Coatings

N. VINSON

who discusses in the paper he contributes to the convention the very extensive and growing application of plastics coatings in a variety of industries today, is managing director of Plastics Coatings Ltd., a company which he launched nearly ten years ago. Now employing some two hundred people, his organisation has grown to what is described as the largest coating company specialising in this type of work in the Western hemisphere.

Plastics-coated Steel

F. H. SMITH

is London manager of John Summers & Sons Ltd. He was educated at Modern School, Streatham, and attained his A.M.I.E.E. at Battersea College of Technology. He served a student apprenticeship with Asea Electric Ltd., and was with that company for a total of ten years. He joined John Summers in 1941, and has been closely concerned with the development of electro-zinc coated sheet, galvanised and plastics coated steel (the latter subject being of particular interest during its recent development).

Composite Structures and Applications

B. R. NOTON

was born in Bath in 1928. In 1948 he completed a student-apprenticeship course at the Bristol Aeroplane Co. and the Merchant Venturers' Technical College at Bristol. From 1949-51 he took the post-graduate course in aeronautical science at the College of Aeronautics and received the diploma with distinction in aircraft design. Subsequently he was employed as scientific officer at the Aeronautical Research Institute in Sweden, and in 1958 was appointed technical assistant to the director.

Loading Statistics as a Basis for Structural and Mechanical Design

T. HAAS

has been head of the design advisory service of the British Welding Research Association for the past two years. He received his education in Czechoslovakia, and obtained an honours degree at Prague German University faculty of mechanical engineering, and has had an extensive background of aircraft engineering, starting with post-graduate studies in aeronautical sciences and including four years as a design engineer on air frames. During the 1939-45 war he was on the research staff of the Royal Aeronautical Society engaged on structures and aerodynamics. After a period as a freelance consultant in London and abroad when he was concerned with mechanical design, he joined Bristol Aircraft Ltd. as head of its fatigue laboratory for six years.

Influence of Corrosion on the Design of Chemical Plant

E. WARDE

was educated at Hove County School for Boys, Brighton Technical College and Imperial College of Science and Technology. He was awarded a B.Sc. (Special Chemistry) degree by London University in 1946, and, after a post-graduate chemical engineering course, he received the Diploma of Imperial College. In 1953 he joined Henry Wiggin & Co. Ltd., in Birmingham, as chemical engineer in the technical section of their sales department.

Sintered Friction Materials

R. I. BLACKWELL and J. C. HEWITT

are on the staff of the Sheepbridge Group, where their work is concerned with the study of sintered friction materials.

Mr. Blackwell studied at Mansfield Technical College and later acted as a laboratory steward there until 1942 when he joined Sheepbridge. After war service with the R.A.F. he spent two years as a foundry technician and then joined Sintered Products Ltd. in 1949, moving some four years later to the company's department for sintered friction materials where he is now development engineer. In the course of his work with these materials, he visited the U.S.A. in 1956 to study latest techniques there.

Mr. Hewitt, who studied at Chesterfield College of Technology before obtaining his B.Sc.(Eng.) at London University, joined the Sheepbridge group in 1945. Five years later he became development draftsman in the company's central research and development department; in 1957 he became project engineer in this department, a position he now occupies.

Sintered Porous Media

G. BREWER and A. CLAYTON

are both concerned with the development and production of sintered porous materials with the Sheepbridge group of companies.

Mr. Brewer studied at Chesterfield College of Technology, where he obtained his H.N.C. in metallurgy. He joined Sheepbridge in 1943 and, after miliary service lasting from 1945 to 1948, he became manager of the company's foundry producing cast iron stick. In 1959 he was appointed technical engineer for porous media at Sintered Products Ltd. He serves as a member of the committee for the production of British Standards relating to metallic filter materials.

Mr. Clayton, who was also educated at Chesterfield, joined Sheepbridge Engineering Ltd. in 1947 and was an analytical chemist there until 1952. After two years' service with the R.A.F., he rejoined Sheepbridge as a research metallurgist, and is now concerned with the study of sintered porous materials.

Use of Aesthetics in Machine Design

F. C. ASHFORD

is an industrial design consultant. He has been an industrial designer since the middle 'thirties, when he was an assistant in Raymond Loewy's London office. After the war he formed Scott-Ashford Associates with Douglas Scott. From 1956-59 he was reader in industrial design (engineering) at the Royal College of Art. He is now in private practice as a consultant, concerned principally with the design of capital goods, and is lecturer and adviser on industrial design courses to the C.o.I.D., the B.T.C. and A.E.I.

Relationship of Engineering and Industrial Design and the Role of the C.o.I.D.

W. H. MAYALL

has since 1959 been with the Council of Industrial Design in London as industrial officer responsible for capital goods, promoting an aspect of design which, he believes, should be an essential counterpart of technical development. He spent his earlier years at Heenan & Froude Ltd., joined Flight Refuelling Ltd. in 1941 and subsequently became project engineer and later chief mechanical engineer at Tiltman Langley Ltd., where he was responsible for a variety of development projects.

Holders of conference season tickets will receive a bound volume of all lectures; holders of daily tickets will receive copies of only those lectures which are to be read on that particular day. Applications for tickets should be made without delay to: The Secretary, E.M. & D. Conference, Drury House, Russell Street, London, W.C.2.

DESIGN WITH CAST COPPER-BASE ALLOYS

The author describes some of the recent interesting developments in the bronze and brass founding industry, including research on gunmetals; new alloys for pressure tight castings; bearing bronzes; new casting methods; shell moulding; and the control of metal treatment and melting

by G. SWINYARD*, M.Sc., A.I.M.

DURING the past decade many new and interesting copper-base alloys have been developed for casting work. Furthermore, many of the standard gunmetal and bronze specifications have been re-examined with a view to providing designers and industry in general with greater satisfaction and reliability than they have had hitherto.

Alloy Selection

The recently published BS 1400:1961 Schedule for Copper Alloy Ingots, and Copper and Copper Alloy Castings, incorporates many of the modifications and new alloys. The publication of this standard schedule provides the designer with the mechanical properties and chemical composition of an alloy but it does not give information as to how that alloy may be employed to its best advantage. The Association of Bronze and Brass Founders therefore, has compiled a handbook which gives valuable information on the selection and usage of these alloys. The handbook, now published by the A.B.B.F. as *Copper and Copper Alloy Castings, Companion Volume to BS* 1400:1961, is a product of the combined efforts of specialists drawn from the technical staffs of members of the Association. It must be emphasised here that BS 1400 and the *Companion Volume* should be used in conjunction with each other. The study of these publications will enlighten many on the potentials and applications of copper-base alloys, and the purpose of this article is to arouse designers' interest to approach founders for more detailed information on the usage of copper-base alloys coupled with advice on specific casting design or, alternatively, the application of casting techniques mentioned in the *Companion Volume*.

New advances in copper-base alloys, coupled with new casting techniques, suggest that the bronze and brass foundry industry is now poised, ready for an expansion which is overdue. In some instances copper-base alloys are replacing fabrications, and they are also being used as alternatives to other metallic and non-metallic materials.

*Mr. Swinyard is on the staff of The Phosphor Bronze Co. Ltd., and is chairman of the A.B.B.F. technical committee.

Research on Gunmetals

During the course of the many years of discussion which has resulted in BS 1400:1961, there has been much valuable research into properties of gunmetals. These alloys are used extensively for hydraulic pumping equipment, and the problem of pressure tightness has always been raised by designers. Although many modifications can be made to casting design, it is appreciated that it is not always possible to produce castings without variations in wall thickness. Certain alloys, such as Admiralty Gunmetal or G.1.C., have been used because of high strength but have been found to leak during pressure testing; LG.2.C. has been found to be very good for pressure tightness, but in a number of cases it does not have the high strength required for particular components; for many years, LG.3.C. has been used because it was theorized that it was an alloy which would give the optimum properties of strength and pressure tightness.

This latter alloy has been adopted by many Service and industrial design offices, but it has always presented grave problems to the founder. Research carried out by the British Non-Ferrous Metals Research Association has now proved that this alloy is unsuitable for pressure-tight conditions. The elimination of LG.3.C. presented a problem, because this meant that there was no alloy available which would balance strength against pressure tightness.

New Alloys for Pressure-tight Castings

Further research by the B.N.F.M.R.A. has shown that an alloy with the nominal composition of 7·5% tin, 2% zinc, 3% lead and remainder copper can give the best combination of mechanical properties and pressure tightness. This alloy has been publicised in a paper called "Gunmetals—Choosing the Best"[1]. Parallel with this research The International Nickel Co. (Mond) Ltd. carried out other work[2], as a result of which another alloy giving similar strengths and pressure-tight properties has been evolved due to the addition of 2% nickel. These alloys have now

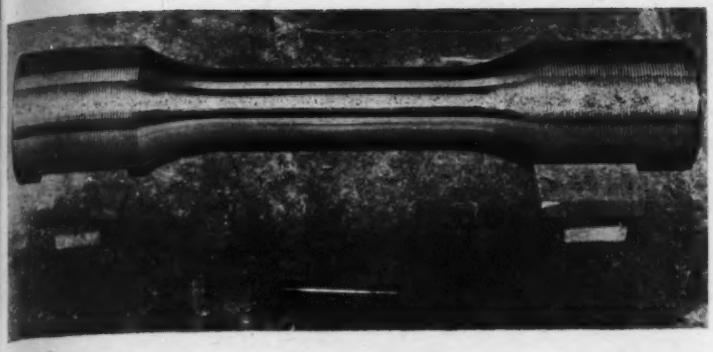


Fig. 1. Large gunmetal test-bar 3 ft. long by 4 in. dia. in breaking area, in comparison with 0·564 in. dia. standard test-bar. (International Nickel Co. [Mond] Ltd.)

been considered together, and as a result BS 1400 contains a new alloy LG.4.C. which is based on the research on both B.N.F.M.R.A. and Mond Nickel gunmetals.

One particular aspect of the gunmetal containing nickel is that it maintains its properties in thick sections, and figures of 17·1 t.s.i. and 25% elongation have been obtained in 4-in. sections. These properties have actually been determined[1] by the use of special large test-bars. Figs. 1 and 2 give some idea of the size of the test-pieces used, while Fig. 3 shows a 4-in. dia. gunmetal test-bar in the machine immediately after breaking.

It is strongly recommended that wherever pressure-tight gunmetal castings are required, either LG.2.C. or LG4.C. be used in preference to LG.3. From the foundry point of view, and as advice to designers, this recommendation cannot be stressed too strongly. It has been realized, however, that 88/10/2 or G.1.C. may be required for specific cases—it has slightly higher properties than LG4.C., and research has proved that with a lead content of 1% the properties are improved considerably together with pressure tightness. Allowance has been made for the increased lead content in the new British Standard. Foundries using the B.N.F.M.R.A. and Mond Nickel gunmetals and also the modified G.1C. prior to the publication BS 1400:1961 have reported marked improvement over LG.3.C., and many design offices are now adopting these alloys.

The best alloys for the production of pressure-tight castings contain substantial amounts of lead, and this element has significant effect on the machining of castings. Cutting speeds and feeds may be increased with consequent economies in finishing operations. Wherever pressure tightness is required machining allowance should be kept to a minimum; this will avoid removal of too much of the close-grain material at the surface of the castings.

Another gunmetal containing nickel[2] has been developed with properties in excess of those attained with G.1.C. This alloy is known as BS 1400:1961 G.3.C., and it is interesting to note that by heat-treatment (BS 1400 G.3.W.P.) these properties may be developed to give a minimum tensile strength of 28 t.s.i. and a minimum elongation of 3%. The 0·1% permanent set stress would be 18 t.s.i. This alloy has had considerable success due to its resistance to corrosion, particularly in atmospheres containing sulphur dioxide. Resistance to abrasion and wear is another of the more important properties of G.3.W.P.

Increased Mechanical Properties

Although the initial emphasis on pressure tightness has been placed on the leaded gunmetals, other copper-base alloys can be used to obtain this property, among them the aluminium bronzes, the high-tensile brasses and the CMA. alloys. These series of alloys have greatly increased mechanical properties. The lowest properties of 30 t.s.i. with

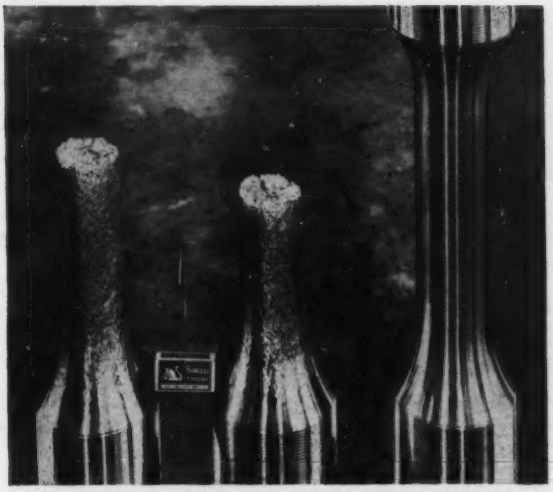
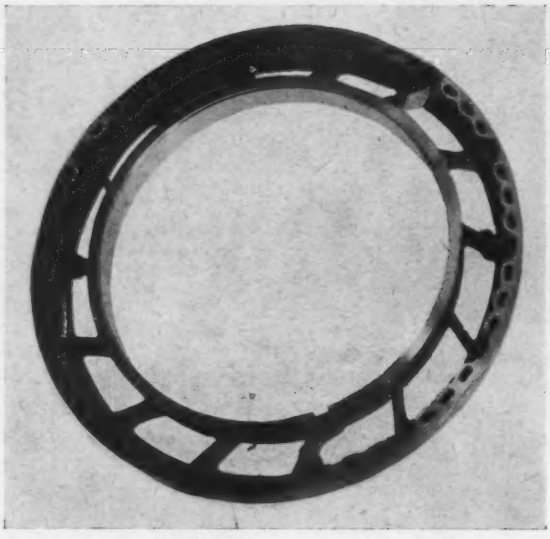


Fig. 2. Gunmetal test-bar before and after failure. (International Nickel Co. [Mond] Ltd.)

Fig. 3. Large gunmetal test-bar immediately after failure. (International Nickel Co. [Mond] Ltd.)

20% elongation are obtained with the high-tensile brass BS 1400 HTB.1-C. Strengths of 48 t.s.i. are obtained by the use of HTB.3-C., but this alloy should only be used where no corrosive conditions are likely to prevail because it is prone to the phenomenon known as stress corrosion. Aluminium bronzes that do not suffer from this problem of stress corrosion have been used for a number of years. These alloys have given general satisfaction, particularly when special consideration is paid to design and the founder is consulted at any early stage. In recent years, however, new alloys developed under the trade name of Superston have been introduced and, because of their success, have been included in BS 1400:1961 as CMA.1-C



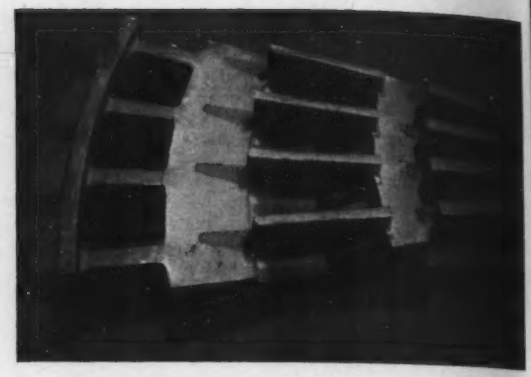


Fig. 5. 500-lb. high-strength alternator stator segments produced in CMA.1-C (Superston 40). (J. Stone & Co. [Charlton] Ltd.)

Fig. 4. 245-lb. end ring in high-tensile brass HTB.1-C replacing steel. (Phosphor Bronze Co. Ltd.)

and CMA.2-C. These alloys were developed essentially for the manufacture of propellers, and have had marked success for marine purposes. They have increased fluidity compared with that of the aluminimum bronzes, and CMA.2-C now provides designers with the opportunity of obtaining copper-base alloys with tensile strengths up to 48 t.s.i. without the risk of stress corrosion. Furthermore, because of the increased fluidity, section thicknesses may be reduced on castings in comparison with the thicknesses required for alloys of lesser strength.

Resistance to Corrosion

All alloys are not corrosion resistant under every condition, and even stainless steel has its limitations. CMA alloys are resistant to corrosion, and in a wide variety of respects have in many cases replaced stainless steel. Specific mention here may be given to phosphoric acid and sulphuric acid, particularly where conditions are non-oxidising or the degree of aeration is comparatively low. Although reference to the heat-treatment of CMA.2 is not made in BS 1400: 1961, it is known that by heat-treatment a Brinell Hardness of 350 can be obtained, together with good tensile strength and a reasonable percentage of elongation.

While new alloys have been developed, research has been instituted for the purpose of determining important properties—including creep and fatigue—other than those provided in the Schedule.

Castings versus Fabrications

The challenge to other materials has been touched on in connection with corrosion resistance, together with the possibility of using aluminium bronzes and CMA alloys as a replacement for stainless steel. In a number of cases, castings in these alloys together with high-tensile brasses have been shown to be more economical propositions than the use of a fabrication.

Cutting and the subsequent welding of plate sections is a very expensive proposition. The full cost of the operations involved may be glossed over because of the cheapness of the basic material, and can only be fully evaluated in terms of total cost of the fabricated component including the many man hours and welding jigs that are required. Frequently, this has been in excess of the cost of a casting.

Many companies are now using castings in the alloys mentioned above as alternatives and in preference to fabrications. If the resulting casting is to be built into a major assembly there are welding limitations on the use of high tensile brass, but aluminium bronze can be welded, and CMA alloys in particular have been incorporated in other assemblies by welding.

In another sphere and to a lesser extent, high conductivity copper has replaced some fabrications. HCC.1 and HCC.2 appear for the first time in BS 1400: 1961 as casting materials. Although new to BS 1400, a number of companies have for a long time manufactured castings in high conductivity copper, and cut-up tests on castings have shown that the conductivity of a sound casting can easily surpass the 95% IACS set out in the specification.

Considerable work has been done in the switch gear field, and castings have replaced many light fabrications which have hitherto been based on sheet copper subsequently assembled by brazing or silver soldering. At least one company has manufactured castings weighing up to 500 lb. in high conductivity copper.

Effect Of Impurities

While these new and exciting developments open up many new fields for bronze and brass castings as well as fresh trains of thought for designers, mention must also be made of the excellent and reliable service which established copper-base alloys have given over a large number of years. But even these alloys have been re-examined at the instigation of the A.B.B.F. with the object of determining the reasons for apparently freak failures which have been experienced with them from time to time. In particular, attention has been paid to impurity limits in many of the standard bearing materials which are used with a view to increasing and maintaining a more satisfactory working life.

A few years ago there was a severe challenge in certain spheres to the standard cast bearing materials from fabric and other plastic bearings. There were, at one time, grave fears on the part of the founders that these new materials would affect their established lines, but it would appear, after a period of time, that the challenge has not had such great effect as was at first expected.

It is unwise to be complacent about new developments, and it is therefore pleasing to note that the A.B.B.F. has

Fig. 6. Boat fittings in CMA.1-C replacing stainless steel. (J. Stone & Co. [Charlton] Ltd.)

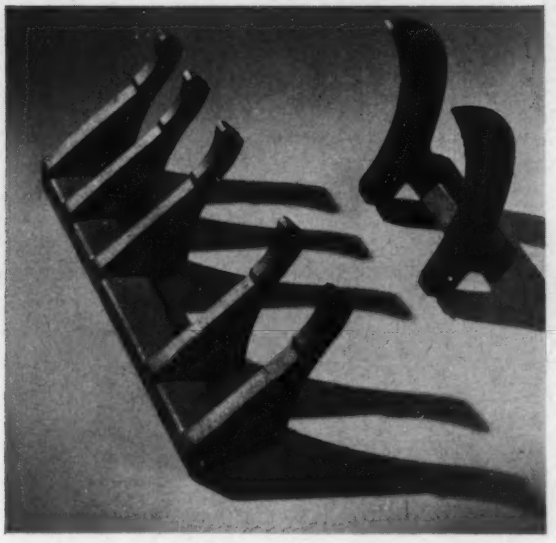


Fig. 7. Cast copper base alloy guides for cigarette-making machines; these replaced a welded assembly. (J. Stone & Co. [Charlton] Ltd.)

prompted the revision of many of the standard bearing specifications.

Bearing Bronzes

The conception of bearing design is influenced by the many and varied service conditions. It is, of course, impossible to discuss all the permutations of the conditions which can arise. If there is any doubt at all as to the selection of a bearing alloy, it is most important to discuss conditions of service with a founder and thus arrive at the most suitable alloy. Phosphor bronzes are of course the best-known copper-base bearing materials and, in this range of alloys, BS 1400:1961 PB.1-C is well known for its suitability with hard shafts, high speeds and high loads in well-lubricated conditions.

In the majority of specifications for phosphor bronze worm wheels and gears, BS 1400:1961 PB.2-C is normally used, but once again good lubrication is essential. Under conditions of very heavy loading phosphor bronze is employed, but in conditions of extreme loading, such as those attained in crushing machinery and in dies for metal forming, the aluminium bronzes are more suitable. For softer shafts or for conditions of doubtful lubrication or errors of alignment, the alloys LB.1-C or LB.5-C are more frequently employed.

These are of course only broad principles, and although reference to alloy selection has been limited, it is suggested that further discourse is unnecessary in view of the excellent and detailed treatment accorded to the subject in the *Companion Volume*.

Brass for Sand- and Die-casting

Where the conditions of service of casting components are not particularly onerous, it is natural that the cheaper materials will be used. Thus brasses are quite widely used as sand castings, but if the quantities required justify the initial expenditure for tooling, die castings may be employed. Die castings present a much cleaner appearance than sand castings, but alloy composition has to be more stringently controlled. A particular feature of the brasses is that they are most suitable for nickel and chromium plating, and are therefore used extensively for ornamental work. Special reference may be made to brasses listed in BS 1400:1961. SCB.1-C is suitable for pressure-tight castings, but SCB.4-C (more commonly known as Naval Brass) has a greater corrosion resistance due to its tin content, and is more widely used for ships' fittings and pump bodies. SCB-5-C is used where the castings are to be incorporated in fabrications by brazing.

New Casting Methods

With all this interesting development in the brass and bronze casting field, the questions which must be asked by designers and buyers alike are: What assurance is there that sound castings can be obtained? How do we get the best out of these new alloys? What guarantee can founders give of maintenance of these properties? These aspects have not been lost on the foundry industry, and new methods of casting have been evolved with a view to eliminating faults, producing closer tolerance castings and giving better physical properties.

Continuous and Semi-continuous Casting

The most interesting method of casting which has been established over the past few years has been the continuous casting of copper-tin alloys, including phosphor bronzes, gunmetals and lead-bronze alloys in lengths suitable for use on automatic machines. Molten metal passes from the furnace into a main receiver or tundish, from where it passes through a water-cooled die, solidifies en route and continues its passage as solid or cored bar. This continuously cast material is cut off at any required length. There are many advantages to be gained by the use of continuous cast materials; these include: (a) lengths up to 12 ft. may be obtained for use on automatic machines; (b) machining can be cut down to one-sixty-fourth of an inch; (c) shrinkage porosity is non-existent; and (d) controlled casting conditions give mechanical properties which are consistently high and well in excess of those normally obtained by other casting processes.

The material may cost a little more when based on price per lb., but where $\frac{1}{4}$ in. machining is allowed on normal sand-cast material, the economic advantages of continuous-cast material are obvious. For example, to machine 1 ft. of bar to 2 in. dia. requires 1 ft. of $2\frac{1}{4}$ in. dia. sand-cast bar, weighing 15·4 lb. To machine the same size from continuous-cast material, allowing as much as $\frac{1}{8}$ in. cut, requires 1 ft. of $2\frac{1}{16}$ in. dia. weighing 12·8 lb. The larger sizes show greater savings in weight, and more than offset the

increase on the basic casting price per lb. The saving on machining must cause even greater economies, particularly as the reliability of this material is so hard to fault.

Continuously-cast material can be supplied for standard use up to 5½ in. outside diameter, and it may be cored depending on size to give a wall thickness of ¼ in. One member company has developed the process for a special purpose, and has manufactured some continuously-cast material in sizes up to 40 in. dia.

Shell Moulding

Just after the second World War, the shell-moulding process was introduced to this country, and for various reasons its natural development was retarded. Once the main obstacle against general usage of shell castings was removed, the process was used for many applications where it was unsatisfactory. Founders and designers alike fell for sales talk, attempted the impossible, and subsequently found themselves in many embarrassing situations. For a period, the shell-moulding process fell into disrepute.

With all this in mind, however, the shell-moulding process still has many advantages, and when used rationally is an improved and important addition to the methods of manufacturing castings.

Shell-moulded castings have a greater constancy of dimensions than those manufactured by normal sand-moulding, but it must be pointed out that the greater the accuracy required on castings the more costly is the pattern equipment. The standard of finish and accuracy of the pattern equipment alone can determine the ultimate accuracy of the casting, and this is a point which must be strongly emphasized.

Shell mouldings present much cleaner and smoother surfaces than sand castings, and because of the constancy of the dimensions, machining allowances may be small.

Many companies allow only $\frac{1}{32}$ in. machining for specific types of castings, and it is known that a number of companies are screwcutting threads from shell-moulded castings without any previous roughing operation being carried out. Once the correct running and feeding technique has been achieved there is a greater constancy with respect to soundness by comparison with sand castings, because the runners and risers are standard and not subject to human variables.

Centrifugal Casting

Although centrifugal casting is not a new foundry technique, its usage appears to be known only to comparatively few people outside the foundry world. It produces a denser casting by the application of centrifugal force to the molten metal. In addition, however, this process possesses an important metallurgical advantage over normal casting methods. As molten metal is fed into the rapidly rotating die it solidifies against the chill wall, and progressively builds up the required wall thickness as more metal is poured. This directional solidification of the bronze provides a uniform temperature gradient from solid to liquid metal and produces sounder castings having better physical properties than can be obtained by any other process.

This process is most widely used for the manufacture of bushes, specifically phosphor bronze or leaded bronze bushes as well as rings from which gears are cut. The technique also overcomes the problem of porosity, which can arise with rather long thin-walled bushes in high-tensile brass, aluminium bronze or CMA alloys.

In the case of leaded bronzes, however, there is a danger that alloy segregation will occur on the periphery of the casting unless special care is taken during the casting operation. This is understandable when one realises that the higher specific gravity of lead exerts greater centrifugal force as compared with the remaining constituents. This is a point which is given special consideration by A.B.B.F. specialists in this type of casting.

Fig. 8. Holding pot and die used in a continuous-casting process. (Tin Research Institute.)

Fig. 9. Transfer of molten brass from furnace to holding pot. (Tin Research Institute.)

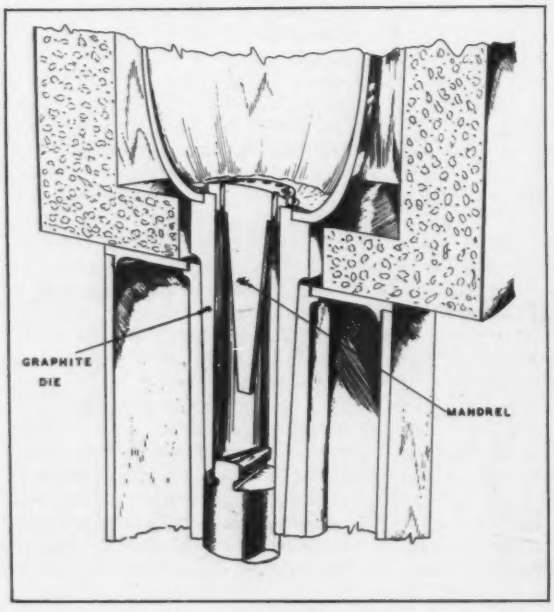


Fig. 10. Diaphragm valve seats which are supplied as shell mouldings. (J. Stone & Co. [Charlton] Ltd.)

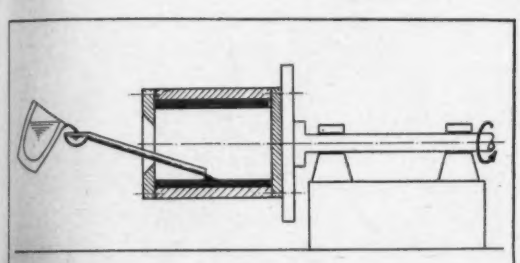


Fig. 11. Centrifugal-casting machine, showing method of casting a parallel bush. (Eyre Smelting Co. Ltd.)

Large centrifugal castings are made in connection with the manufacture of paper rolls, and castings up to 28 ft. long and 3 ft. dia. are not uncommon. In normal practice, by using a horizontal technique, centrifugal castings are made up to 3 ft. long and about 20 in. dia.; however, by using a vertical technique, castings may be made up to 5 ft. dia., but the depth is usually limited to something of the order of 18 in.

Gravity Die-casting

Gravity die-casting is widely used for aluminium bronzes, high-tensile brass and CMA alloys. Certain brasses are also gravity die-cast, and those recommended for this technique are denoted in BS 1400 with a prefix D, e.g. BS 1400 DC B.1-C. The use of gravity die-castings is governed to a large extent by economics; in certain cases, alloy steels which are costly and hard to machine must be used for dies, and it is essential that the initial cost of the die be offset by the quantity of castings produced or by savings in weight allowed for machining. Close dimensional accuracy may be obtained with excellent surface finish allowing either a large reduction or even the elimination of machining, and by reasonable discussion on design certain sections may be safely reduced because of the higher mechanical properties obtained.

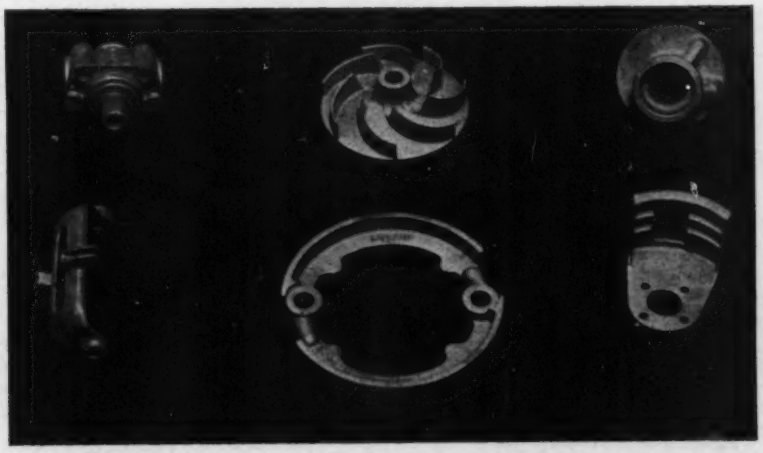


Fig. 12. Aluminium-bronze diecastings for the motor industry. (Sagar Richards Ltd.)

The design of complex castings should always be discussed with the foundryman, because much valuable assistance can be given in connection with changes in section or production facilities. This recommendation is specifically endorsed in connection with the design of components which are subsequently to be die cast.

Sand Casting—New Developments

While discussing all the newer or less-known techniques employed for the manufacture of brass and bronze castings, it is interesting to note that during recent years many new developments have taken place in the sand foundry. New ideas on sands and sand control have been developed.

Among these new sand mixtures one must highlight the CO_2 process. Normally, foundry sand is bonded with some form of clay, but in this process the binder is sodium silicate blended with a break-down agent. After ramming a core or a mould, CO_2 gas is passed through the interstices of the sand. CO_2 reacts with sodium silicate to form a type of silica which acts as a firm binder for the sand grains. Among the advantages gained by using this process are the elimination of many hours of drying time, and the reduction of production cost.

The mould is rigid before the pattern is removed, and therefore the amount of rap required before the withdrawal of the pattern is markedly reduced—this leads to dimensional stability of the casting.

Special surface finishes may be obtained by the selection of graded silica sand to be used in the mixture. Certain phenolic resins have also been used as core-binders, but all these techniques are used at the discretion of the foundryman—this means that nowadays foundrymen have more facilities for the production of sounder and better castings than even ten years ago. This indeed must give the designer some assurance as to the standard of casting which can be produced, but that is of course only part of the picture.

Correct Control

Metal Treatment and Melting: Nitrogen degassing of copper-base alloys was perfected by the B.N.F.M.R.A., and has for many years been employed in industry. Now, thanks to a member of the A.B.B.F., an entirely new method of melting bronze and brass has recently been introduced. Not only does this new "Atmosphere Controlled Rapid Melting" furnace[4] speed up melting and thus reduce costs, it also assists in the elimination of gas porosity and increases melting efficiency to a considerable extent. These techniques, of course, should not be made mandatory requirements by the designer; the foundryman experienced in casting by a particular method can advise on which technique should be employed—bearing in mind suitability to the casting in question, and the economics of the job.

Metallurgical: Metallurgists are playing an even more important part today in the control of materials on the foundry floor, and are backed by many interesting and important control techniques.

In recent years, one member of the A.B.B.F. has been able to lead the way with the application of a new rapid and very accurate form of analysis—the X-ray Fluorescent Spectrometer. Other foundries have installed extensive radiographic and machining facilities, and are thus able to guarantee soundness and quality.

Conclusion

This article has touched on the highlights of some of the interesting developments which have recently taken place in the bronze and brass founding industry. After perusal of both BS 1400:1961 and the *Companion Volume* published by the A.B.B.F., one may see that new alloys have been developed and the older alloys improved; new and better production and control techniques are available; founders are aware of the importance of quality, and have the facilities available to maintain it.

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The author wishes to thank the members of the A.B.B.F. Technical Committee for help in preparing this article.

RESEARCH FOR THE DESIGNER

THE National Engineering Laboratory at East Kilbride recently issued its annual report for 1960, the keynote being co-operation with industry. Three of their major projects which will help to keep British engineering ahead in the world's markets are: application of moire fringe techniques to the automatic correction of the table drive on standard gear-hobbing machines; development of hydrostatic power transmission; and cold extrusion of steel.

The response from industry to the first two projects has been good, David Brown Industries Ltd. collaborating on the gear-hobbing machines, and Armstrong Whitworth (Metal Industries) Ltd. being concerned with one of the hydrostatic transmissions. The cold extrusion of steel has not raised so much enthusiasm from industry; this may well be due in part to the lack of information available to the designer, a point which was raised in *Engineering Materials and Design* recently (page 101, February 1961).

Other work being carried out at N.E.L. includes the study of fatigue of metals at high temperature, particularly in the blading of gas turbines. Experiments have shown that where the blade section is brazed to the root section, a longer life is possible under alternating stresses at elevated temperatures.

The search for new materials has been facilitated by apparatus built at N.E.L. for generating extremely high pressures of the order of 90,000 atmospheres. Present efforts are being confined to the study of the graphite-to-diamond transition, to gain experience in this field. This is to be followed by studies of the nickel-carbon system at high pressures.

The effect of strain rate and temperature on mechanical properties is also being investigated. Generally, an increase in strain rate raises the yield point and reduces ductility, and one aspect of the laboratory's work on the plastic deformation properties is an investigation into the effects of various combinations of rate of change in strain and temperature.

Little is known of the effect of combined creep and vibratory stresses, and work is being undertaken to investigate the effect of vibratory stresses on complex stress creep fractures.

Another study made during 1960 was the effect of size on the fatigue strength of lugs in aluminium alloy. It was found that geometrically small joints showed an increase in fatigue strength over similar joints of a larger size.

Of practical application has been the development of a liquid level indicator which is accurate to 0.01 in., but which has not yet been placed on the market. (This unit is described, together with the relevant electronic circuits, in N.E.L. Fluids Report No. 89.)

AUSTENITIC MANGANESE STEELS

PRELIMINARY studies recently carried out by the Climax Molybdenum Co., of the U.S.A., indicated two promising lines of improving the abrasive resistance of the austenitic type of high carbon steel. In one, the use of special alloy additions to 12% manganese steel was combined with modifications of the conventional heat-treatment to provide improvements in both wear resistance and strength, with little or no loss in ductility. The second line of attack was an exploration of lower alloy contents in high carbon austenitic steels to achieve improved wear resistance at a somewhat lower ductility. Low alloy austenites gave promise of fulfilling these requirements, particularly under conditions of high stress abrasion.

Effect of Composition Modifications

Carbon: In combination with manganese, carbon greatly influences the characteristics of the austenite, including such properties as tensile and yield strength, ductility, stabilitiy and wear resistance. In general, for wear-resistant castings, it is desirable to hold the carbon content at the highest level possible without seriously injuring the ductility of the steel. For the conventional Hadfield steel this is usually in the range of 1·10 to 1·25%. Higher carbon content tends to embrittle the steel.

Manganese: The manganese content of an austenitized and quenched high carbon steel must be above certain minimum limits. For example, a quenched steel containing 1·2% carbon will be fully austenitic when it contains 5 to 6% manganese. The development of high ductility and toughness in the austenite generally requires manganese in excess of 10%.

Chromium, Molybdenum: Heavy-section castings made from the higher carbon grades of austenitic manganese steel are often prone to cracking in the foundry while they cool in their as-cast condition. This is believed to be due largely to embrittlement. It is generally known that chromium additions tend to aggravate this condition. Molybdenum, on the other hand, when present in amounts over 1·5%, produces a globular type of carbide which forms from the melt in interdendritic sites and minimises the development of grain boundary Fe_3C-type carbides. The globular type of carbide formed in as-cast structures of the 2% molybdenum steels has also been observed in heavy sections; it persists with carbon contents up to about 1·7%, and is believed to be of a complex nature.

Nickel: the effects of other alloying elements on the mechanical properties of light-section castings have been summarised, and indicate that molybdenum additions of up to about 2% increase the yield strength without lowering the ductility or tensile strength. Chromium increases the yield strength, although at a slower rate, but lowers the ductility and tensile strength. Nickel does not show a strengthening effect. Additions of chromium in excess of 1% are probably responsible for the reduced ductility of austenitic manganese steels. Observations indicate that, under some conditions, chromium additions do improve wear resistance, although similar or greater improvements may be obtained by lowering the manganese content of a chromium-free steel, with less loss of ductility.

Silicon: This element is normally added in amounts required for good deoxidation of austenitic manganese steel heats; however, it may be added in amounts up to about 2% to produce a moderate improvement in yield strength. It was also noted that higher silicon content tended to throw carbon out of solution in the austenite by precipitating the carbon either as rather massive carbides or as pearlite. This effect was observed both in as-cast steels and in the same steels after various thermal treatments; it would seem, therefore, that where high carbon content in austenite is required for good wear resistance, a higher than normal silicon content would be harmful.

Phosphorus: This element is generally harmful to the mechanical properties of austenitic manganese steel and, since it is one of the important variables in composition, attention is directed to its effects. Above about 0·1% phosphorus, the room temperature ductility and tensile strength drop off rapidly; over 0·6% phosphorus reduces hot strength and ductility, and may cause hot tears in the castings. Weld deposits of austenitic manganese steels appear to be particularly sensitive to phosphorus contents of more than 0·02%.

Wear Resistance

From wear tests it has been possible to summarise the influence of manganese, carbon, molybdenum, and chromium plus molybdenum, on abrasion factors of solution-treated austenitic steels. It is evident that best wear resistance is obtained in an austenitic steel when the manganese is low. It is further indicated that carbon should be at the highest level which can safely be retained in solution.

Austenitic manganese steel normally has relatively poor resistance to scratching or low stress types of abrasion, but is used under certain conditions for such applications. An example is slurry pipe for back filling mine stopes, where occasional bending stresses or rough handling might cause breakage of less ductile materials.

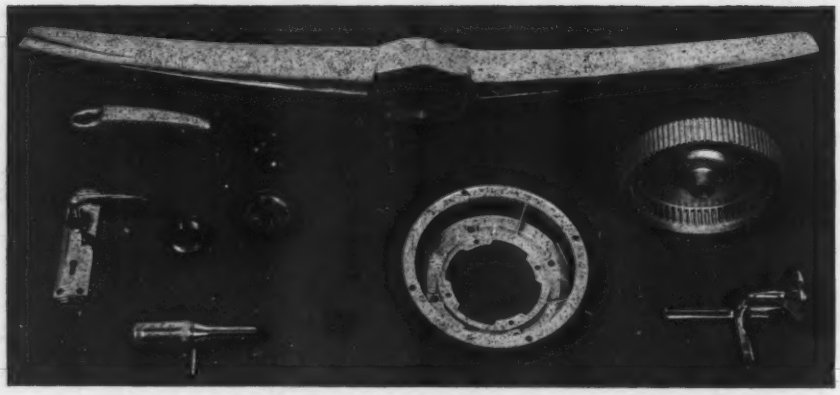
Summary and Conclusions

Austenitic steels having a combination of good mechanical properties and improved resistance to gouging abrasion are produced when carbide dispersions are developed in the 12% manganese high carbon types. The carbide dispersions, together with grain refinement, are obtained by combining a 2% molybdenum addition with a special dispersion hardening treatment. This dispersion heat-treatment involves a pearlitic treatment at 593 deg. C., followed by a re-austenitic treatment at temperatures ranging from 871 to 1,038 deg. C.

Service experience with dispersion hardened 12% Mn, 2% Mo, austenitic steel, with a carbon range of about 1·15 to 1·35%, indicates that this type of steel has better wear resistance than the Hadfield or 2% chromium types of austenitic manganese steel, when used for example in cone crusher liners. The 12% Mn, 2% Mo alloy exhibits improved mechanical properties in heavy-section castings.

It has been shown that an austenitic steel with a combination of moderate ductility and improved wear resistance is obtained from a composition containing about 6% manganese, 1% molybdenum and 1·3% carbon. This steel is solution treated by water quenching from a temperature of between 1,040 and 1,090 deg. C. Service tests in ball mill liners, grates and scoop lips, and in jaw crusher liners and grizzly screens, indicate that this steel when solution treated has good resistance to both the grinding and gouging types of abrasion.

This article is made up of extracts from a paper by T. E. Norman, D. V. Doane and A. Solomon (*Transactions* of the American Foundrymen's Society, vol. 68, 1960).



Selection of typical zinc-alloy die-castings—some chromium plated, some enamelled, and others in the as-cast finish. (Zinc Development Association.)

KNOW YOUR METALS — ZINC ALLOYS

Continuing our series of articles for the junior designer who has not been trained in metallurgy, this article deals with the zinc alloys which are of primary importance in engineering design

by A. R. L. CHIVERS*

FOR engineering purposes the important zinc alloys are those containing 4% aluminium and 0.04% magnesium, the rest being special high-purity zinc of at least 99·99% purity. Most of the zinc alloy used for pressure die-casting has this composition, but sometimes additions of copper are made up to about 2¼% to give extra strength and hardness. Zinc-aluminium alloys with more aluminium have been investigated and used from time to time, but so far none has been found to have more than limited use either where some particular property, or combination of properties, is of special value, or as war time substitutes for unobtainable materials. In what follows the author describes the important die-casting alloys first, and then says a little about the others.

Die-casting Alloys

Zinc alloys have been used for pressure die-casting in steel dies for over fifty years, but it was not until the late 1920's that the modern type of stable alloy was developed and began to find a multitude of applications, particularly in the motor industry. Before then, die-castings had been made in alloys based on lower-grade zinc containing lead and cadmium as impurities and with additions of tin as well as the aluminium. Research showed that zinc-aluminium alloys were susceptible to inter-crystalline corrosion under humid conditions when any of these other metals were present even to the extent of a few parts per hundred thousand. This accounted for the not infrequent cases of die-castings swelling, distorting and blackening in use, and sometimes becoming so weak that they could be broken in the fingers. This discovery, and the simultaneous availability of special high-grade zinc in which lead and cadmium were each kept at below 0·003% and tin (not normally found in zinc anyway) below 0·001%, allowed zinc alloy die-casting to become a major mass production process, nowadays running at a world annual output of around 500,000 tons. The small addition of magnesium was made to counteract the effects of the residual traces of lead and cadmium.

When BS 1004 was first published in 1942, Alloy A (the copper-free alloy) was recommended for use only when the utmost dimensional stability was needed, Alloy B (with 1% of copper) being considered the general-purpose alloy. Experience with Alloy A during the war, however, led die-casters in Britain to prefer it for most purposes, and soon Alloy B was only chosen for applications where its slightly greater strength and hardness were an advantage — it is still commonly used for zip-fastener sliders. At one time the similar alloy with 2¼% of copper, which is harder still, found some uses, but its benefits were marginal and it is scarcely used at all now for pressure die-casting, though it has other applications to be mentioned later. The copper-containing alloys are liable to aging changes, with the result that they lose impact strength (i.e. tend to become brittle) if they are held for prolonged periods at high temperatures. They also undergo a more marked shrinkage on aging, though this is seldom important and can be overcome by a heat-treatment, for example holding at 100 deg. C. for 3-6 hr. The same stabilising treatment can be applied to Alloy A when the finest limits must be held, but is rarely necessary in practice.

The main properties of the alloys are set out in Table 1. Their strength and impact resistance are excellent and allow them to be used for a variety of stressed components, such as gears, ratchets, levers, handles, brackets, and as bosses and hubs connecting steel parts, e.g. steering-wheel hubs in which steel spokes are cast as inserts in the die. Ductility is sufficient to allow castings to be swaged and spun, and to incorporate integral rivets which are subsequently spread over a mating part.

*Zinc Development Association.

The low melting point of the alloys (387 deg. C.) restricts their use at high temperatures. Alloy A can be used unstressed at temperatures up to 150 deg. C., and stressed up to 100 deg. C. Alloy B should not be used where it is likely to become hot, because of its loss of impact strength already mentioned. The only property which deteriorates significantly at low temperatures is the impact resistance, though ductility is also reduced. Parts likely to be subject to blows at temperatures below about 10 deg. C. should be designed with thick enough sections. At room temperature and above, zinc alloy is much more resistant to impact than most other cast materials of similar shape, but it differs in being affected by low temperatures.

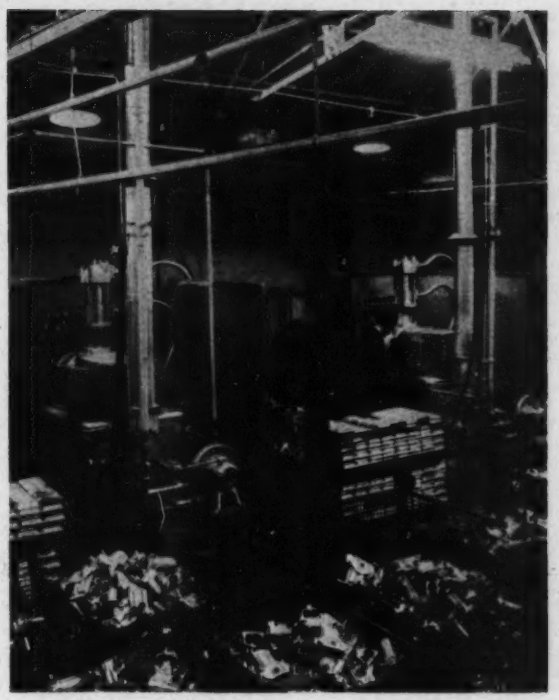
Zinc alloy die-castings hold their dimensions very well, and they are used quite extensively to make components of electrical and optical instruments whose stability is essential to the working of the assembly. Furthermore the low casting temperature, about 410 deg. C., means that the dimensions of individual castings can be held to close tolerances when it is necessary. In the interests of economy, however, fine tolerances should not be demanded where they are inessential. The Engineering Standards available from the Zinc Alloy Die Casters Association, 34 Berkeley Square, London, W.1, should be consulted when die-castings are being designed.

The high-purity zinc die-casting alloys have good resistance to corrosion, like zinc itself. For engineering components they generally need no surface treatment—hand tools, gears, various mechanical parts of cars and office machinery, and electrical equipment may be cited. Nevertheless, many die-castings are plated, painted or given a chemical finishing treatment, either to improve their appearance or to enhance their resistance to some particular corrosive conditions. Plating sequences usually begin with the deposition of a layer of copper at least 0·0003 in. thick, and this is most often followed by nickel and finally chromium. For die-castings which are to be exposed to corrosive outdoor atmospheres, e.g. car door handles and trim, the nickel should be at least 0·001 in.

Table 1.

Properties of zinc-alloy die castings (measured on die-cast test-bars).

	BS 1004 Alloy A	BS 1004 Alloy B
DESIGNATION:		
Physical Properties:		
Specific gravity	6.7	6.7
Weight of 1 cu. in. (lb.)	0.24	0.24
Melting point (°C.)	387	388
Solidification point (°C.)	382	379
Solidification shrinkage (in./ft.)	0.14	0.14
Thermal expansion per °C.	27×10^{-6}	27×10^{-6}
Electrical conductivity (mhos/cm. cube at 20°C.)	157,000	153,000
Thermal conductivity (cal./sec./sq.cm./cm./°C. at 18°C.)	0.27	0.26
Mechanical Properties—(a) After five weeks normal aging (b) After eight years normal aging		
Ultimate tensile strength (t.s.i.)		
(a)	18.5	21.7
(b)	16.0	18.9
Elongation (% on $2\times\frac{1}{2}$ in. dia.)		
(a)	15.0	9.0
(b)	20.0	14.0
Charpy impact strength (ft. lb. on $6\times\frac{1}{2}\times\frac{1}{2}$ in.)		
(a)	42.0	43.0
(b)	44.0	41.0
Hardness (Brinell number)		
(a)	83.0	92.0
(b)	65.0	74.0
Shrinkage, from condition immediately after casting (in./in.).		
(a)	0.00032	0.00069
(b)	0.00079	0.00141
Compression strength (p.s.i.)—(a)	60,000	87,000
Modulus of rupture (p.s.i.)—(a)	95,000	105,000
Shearing strength (p.s.i.)—(a)	31,000	38,000



Part of a modern zinc-alloy die-casting foundry. (Armstrong Patents Co. Ltd.)

thick at any point that a 1-in. dia. ball can touch, and recently it has been shown that a worthwhile improvement in the life of the plated coating can be obtained by using "crack-free" chromium at least three times as thick as the conventional chromium finishes. For castings to be used indoors or inside cars, thinner nickel and conventional chromium are quite satisfactory, as specified in BS 1224. Deposits of cadmium or tin or their alloys are best avoided, as there is always a danger that scrap plated castings may find their way to a remelting furnace and contaminate a batch of alloy.

Zinc alloy parts can be stove enamelled, but first need a chemical treatment to secure good adhesion. A proprietary phosphate dip is generally used, but a chromate dip as specified in the Ministry of Aviation specification DTD 923A is also effective, and has advantages when the paint is being applied mainly to improve corrosion resistance. To avoid metallurgical changes in the alloy, stoving should not exceed about ½ hr. at 200 deg. C. or 3 hr. at 150 deg. C. If a chromate pretreatment has been used the temperature should not exceed 150 deg. C. to avoid dehydrating the film. Instead of chemical dips, pretreatment primers (etch primers) can be used. Chromate treatment alone is valuable in counteracting high humidity or contact with drops of water, e.g. condensation.

In general, zinc alloy is not recommended for water-carrying parts of taps and valves, as certain supply waters—notably soft waters rich in carbon dioxide—may cause pitting corrosion. It withstands contact with mild alkalis such as soap and detergent solutions within the pH range 6·5-11. Zinc alloy is not affected by hydrocarbon fuels and lubricants, nor by degreasing solvents and refrigerants of the Freon type.

More than half the world production of zinc-alloy die-castings is for motor-car components such as carburettors, hydraulic shock absorbers, petrol pumps, door handles, boot hinges, grille parts, lamp housings and horn bodies.

The rest are used in: washing machines, food mixers and other domestic equipment; office machinery such as duplicators; electrical equipment; and light engineering components such as brackets, handles, housings, cams and gears.

New Alloys: Recently two new die-casting alloys have been announced. In the U.S.A., there is one like the usual copper-free alloy except that the impurity limits are even finer and so the magnesium content can be reduced giving, so it is claimed, the ability to cast thinner sections. In Germany, the same basic alloy has been given a small beryllium content (approximately 0·005%) and the magnesium has also been reduced. It is claimed that this alloy can also be cast more easily, and further that less oxide is formed on the melt; beryllium is known to reduce oxidation when added to magnesium base alloys.

Forming and Blanking Dies

High-purity zinc-aluminium alloys like those described above, but with a copper content around 2½%, are useful in sheet-metal forming. They are available in sheets for making blanking dies and as ingots for sand casting to produce punches and dies for use in presses and drop stamps. The alloy surface has good lubricating properties, and quite long runs can be obtained with light alloys, mild and stainless steels. Zinc-alloy dies find most use in forming aircraft and coach body components, and are economical for short runs because of the ease with which they can be cast and finished and then remelted for further use.

Moulds for Plastics

The zinc alloy most used for forming dies is also used to cast moulds for thermoplastics. It takes an excellent, smooth finish and the moulds can be made quickly and cheaply, needing little machining to bring them to their final dimensions. Zinc alloy is not suitable for moulding plastics such as polyvinyl chloride that give off hydrogen chloride fumes.

Gravity and Slush Castings

Zinc alloys can be cast in gravity dies, but are comparatively seldom used in this way as the castings, with their coarser grain structure, are inferior in properties to pressure die-castings. For gravity castings, the 2½% copper alloy is best because it casts more easily. As in all zinc-alloy castings, care must be taken not to overheat the alloy in an effort to make it flow better, because magnesium is quickly reduced below the safe minimum (0·03%) if the temperature exceeds 420 deg. C. Most fluxes also remove magnesium chemically and so are best avoided.

Slush castings are made in a zinc alloy with about 5% aluminium, the eutectic composition. This means that the liquid alloy poured back out of the dies when a skin has solidified has the same composition as the initial melt.

The gravity castings are mostly used to provide spares to replace broken die-castings no longer in production, e.g. door handles for old cars. They have also been employed for stressed components, e.g. the tube joints used to assemble camp beds, in which a casting is poured direct on to the end of one of the rods to be joined, which thus becomes a large insert in a small casting. Gravity castings also make very attractive "sculptures" when cast in two-part moulds made of an insulating cellular concrete.

Bearing Alloy

A high-purity alloy with the nominal composition zinc 65%, aluminium 30%, copper 5%, is available in ingot and rod form for casting or machining into bearings. Its main use so far is as gravity-cast half-shells for use in earth-moving equipment. It is said that this type of alloy can be employed in place of phosphor bronze in most instances. The castings are stabilised by heat-treatment and may not be run at high temperatures. Care must be taken to see that the proper clearances are allowed between shaft and bearing, as there is no squeaking to warn of approaching seizure.

RESEARCH ON DESIGN EDUCATION

Sir,

We have read, with interest, Mr. W. A. A. Witham's letter in the September 1961 *E. M. & D.* describing the National Committee for Research into Teaching and Examining Engineering Design, and feel that some of our experiences at Brunel College may be of interest.

We have given considerable attention in recent years to the most suitable way in which mechanical design can be introduced in our Diploma in Technology in Mechanical Engineering, and one of the first results of this has been the recognition by the Hives Council of a "design group" in the final year of the course. Students may choose one of the following groups: Production Engineering, Engineering Design, and Thermodynamics, together with Project, Nature and Properties of Non-metals, Industrial Administration and General Studies.

The extent to which creative design should be introduced at this level is still under discussion. The final year project (on which students spend one day per week for six months with a further period of three months for writing-up) has, in many cases, given scope for creative work. In most cases the project is experimental in nature and students design and manufacture their own rigs and apparatus, sometimes with assistance from their firm. We have found it difficult but not impossible to choose subjects which can be dealt with in the design and manufacturing stages and tested in the time available. Design work which will never go further than the drawing board is not encouraged.

Our first short course dealing with the design of special-purpose automatic machinery was held in the autumn of 1960, and was supported by 112 candidates from thirty-eight firms from all parts of the country. More courses of this type are envisaged, and it is hoped to make a special feature of design studies by senior personnel from industry. In this connection it should be mentioned that we have received a great deal of practical help and encouragement from our industrial friends, and the phrase "integration between college and industry" is beginning to take on a real meaning.

Our views, like design itself, are continually changing, and it is only recently that we have had any clear picture of the part we can usefully play. We have felt that this is an opportune time to review the situation, and are currently arranging a one-day conference on Education and Training for Mechanical Engineering Design, to be held at this College on November 22, 1961. At this conference we hope to make a more detailed statement of our views, and hear the suggestions and criticisms of the firms who support us. I would be happy to forward further particulars to any of your readers who may be interested.

P. H. J. Baker

Senior Lecturer,
Department of Mechanical Engineering,
Brunel College of Technology.

NEW IDEAS IN DESIGN

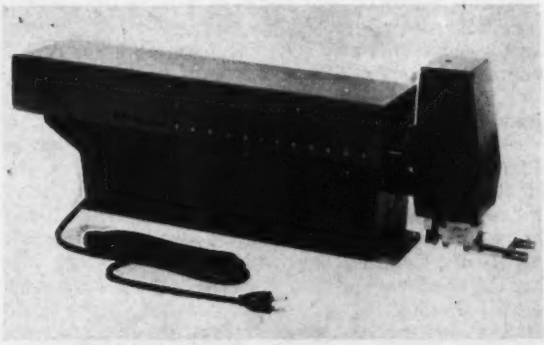
Outstanding products in current manufacture and awaiting development in the U.K.

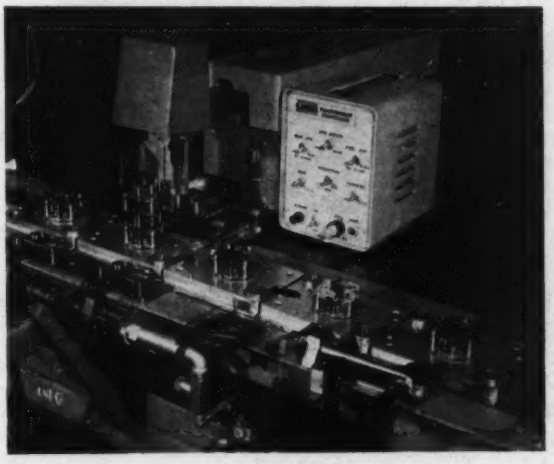
A Stride towards Automatic Assembly

THE Transferobot 200, recently introduced by Burtonwood Engineering Co. Ltd. under licence from the Robodyne Division of U.S. Industries, is an electromechanical device for use on automatic assembly lines. It forms the latest addition to a Robodyne range which includes vibratory feeders, segmented feeder bowls, indexing tables, electronic proximity sensors, parts counters and other automation devices.

The Transferobot 200 is claimed to be capable of performing virtually any repetitive task associated with hand and arm motions. Solid state electronic controls can be used to couple any number of Transferobot 200's together in synchronized co-operation. A wide range of mechanical, pneumatic, magnetic and other accessory "fingers" are available "off the shelf" to handle a wide variety of different components. Mechanical jaws for picking up round or cylindrical components can be provided.

The Transferobot has a sliding carriage which moves horizontally and carries at its outer extremity a vertically moving head incorporating the jaws. Used in conjunction with other machines a large variety of operations, including drilling, stamping, heat sealing, embossing, piercing, forging and bending can be performed. One of the accompanying illustrations shows the Transferobot being used in clock assembly operations. It is claimed that each machine can be arranged so that its activities are either triggered by its neighbour or controlled separately. If a faulty component is found, the controlling devices can signal the fact and bring the line to a halt. The training of an operator to set a line up for a particular task is said to be a simple matter.





New Self-loading Dumper

THE Wakefield 5¼-cu. yd. self-loading dumper is an ingenious application of hydraulic principles combined with good vehicle design. It is intended for on-site moving of earth, rubble, etc., and is made under licence from a West Germany company.

When loading the vehicle the driver faces astern, swivelling his seat through 180°, and uses the 1-cu. yd. shovel to chute the payload into the body. The heavy box-section lift arms are welded to a stout tube which is positioned across the dumper, so that one arm on each side of the body lifts the shovel. For self-loading the shovel is placed at the rear of the body. For travelling the shovel rests securely on the side plates of the body.

The power unit is a Leyland AU 350 giving 100 h.p. at 2,200 r.p.m., and the clutch is a Leyland Type U/C20 with 16-in. dia. single driving plate faced with sintered metal linings. There are ten speeds in either direction, and four wheel drive is provided. The hydraulic control levers are positioned on the steering column. Two-way steering with power assistance is another feature, the seat unit being designed for a shock-proof ride. Foot-operated four-wheel air brakes are fitted, and for parking there is a handbrake which operates mechanically on the rear wheels.

New Armatures have One Coil per Slot

THE General Electric Company, of New York, have recently introduced an improved design of rotor for small universal motors which is claimed to provide greatly improved brush and commutator life. Each slot is wound with one coil. The rotors are provided with twenty-one coils in the G-E 45 frame and eighteen coils in the G-E 31 frame. The principle of this new rotor is explained as follows.

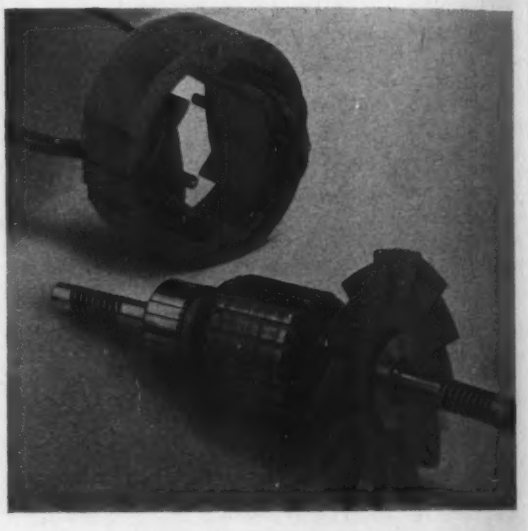
Drawing *A* shows half of a cross-section of a conventional two-coil-per-slot armature. One of the two brushes is in contact with bars *5* and *6*. At this time, the current in the coil must be reversed. The armature circuit is highly inductive, however, and tends to resist this current reversal. A means must be found, therefore, to reduce the energy stored in this armature coil so that reversal of current can be completed. This force is obtained from magnetic flux, produced by the stator, linking with the coil being commutated. In drawing *A*, bars *5* and *6* are contacting the brush, and the current in the coil connected to bars *5* and *6* is being reversed. At this same time, magnetic flux is passing from the field pole toward the nearest rotor tooth. In this case the tooth is ahead of the coil connected to bars *5* and *6*. The result is that the coil passes through magnetic flux and receives the necessary assistance to current reversal.

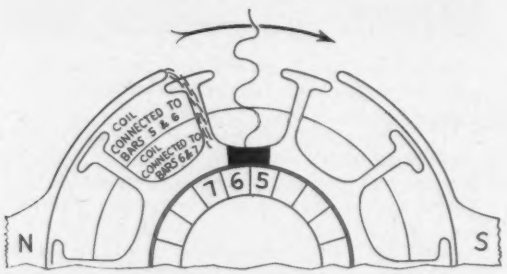
In drawing *B* the armature has rotated, permitting the brush to come in contact with bars *6* and *7*, and reversing the current in the coil connected to bars *6* and *7*. At the same time, magnetic flux is passing from the field pole toward the nearest rotor tooth. In this case the tooth is behind the coil connected to bars *6* and *7*. The result is that this coil does not pass through this magnetic flux that is so necessary to complete current reversal. This means the current has not completely reversed when the brush leaves commutator bars *6* and *7*, and a harmful arc is generated. This causes commutator pitting and rapid brush wear.

The General Electric design, illustrated in drawings *C* and *D*, has only one coil per slot. When the brush is in contact with bars *5* and *6* (drawing *C*), the coil connected to bars *5* and *6* is just beginning to pass through the field flux. The result is claimed to be good commutation with no harmful arc to cause brush wear.

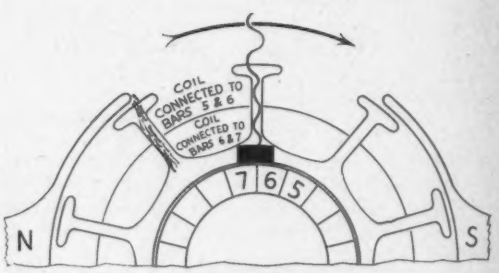
In drawing *D* the armature rotation has brought the brush in contact with bars *6* and *7*. The coil connected to bars *6* and *7* is in the same position that bars *5* and *6* were in in drawing *C*. Again, field flux is giving maximum assistance to current reversal. The result is continued good commutation, with no harmful arc.

An advantage claimed for the new design is that the larger number of slots reduces bar-to-bar voltage and prevents excessive short circuit current as each coil is commutated. Commutation is said to be improved, and armature heating kept to reasonable temperatures.

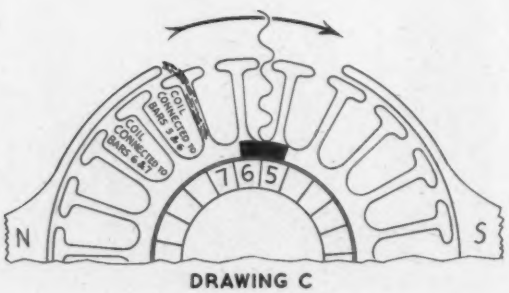




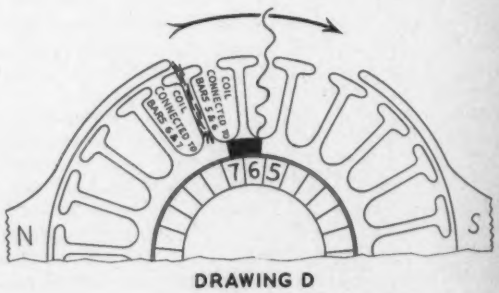
DRAWING A



DRAWING B



DRAWING C



DRAWING D

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

Thermal, Mechanical and Magnetic Treatment of Metals

Engineers of the Moscow Steel Institute have examined methods of combined heat-treatment, deformation and magnetic treatment of alloys in the austenitic class which improve the micro-structure of the metal. In particular, the quenching in a magnetic field practically eliminates temper brittleness.

Considering the heat-treatment and cold work of steels in which a martensitic transformation takes place, it is appropriate to make use of texture orientation in order to increase ductility in the quenched condition, because the simultaneous increase of strength is ensured by the size reduction of blocks during deformation.

Taking into account the dependence of several material properties on the orientation of the elements of micro-structure, the effect of a magnetic field in the transformation from austenite to martensite can be utilised. Magnetisation has to be carried to saturation.

A modification of properties can occur through the following processes: (1) small sub-division of blocks as the result of magneto-striction; (2) substantial size reduction in the fine structure associated with the preferred orientation of martensite crystals with their long axes in the direction of magnetisation; (3) arrangement of martensite crystals in accordance with the virgin structure which, after magnetisation to saturation, forms a general magnetic orientation in all grains. After a combined heat and magnetic treatment, the effect of the boundaries of previously austenitic grains is weakened on certain properties of the steel, notably on temper brittleness.

In the preliminary tests, specimens were placed in a fixture made of non-magnetic steel. In this fixture, the specimens underwent uni-axial tension between heating up in the furnace to the austenitic state and cooling in the quenching bath. The fixture was placed between the poles of an electro-magnet so that the axis of the specimen coincided with the axis of the magnets. A magnetic field in the air gaps of about 2,000 gauss was maintained. Various steels, including commercially pure iron, low carbon steel, medium carbon steel and tool steels, were tested.

On the basis of these investigations, a treatment cycle is proposed. Deformation of the initial structure (before transformation), followed by immediate cooling, produces a fine structure of martensite distinguished by increased strength and improved ductility owing to the formation of an orientated pattern and to an increase in the number of mobile dislocations.

A combined heat and magnetic treatment has been found effective in which, during the transformation from a para-magnetic (austenitic) phase into a ferromagnetic (martensitic) phase, an external magnetic field is superimposed. The mechanical properties of the steel are improved by crystal orientation.

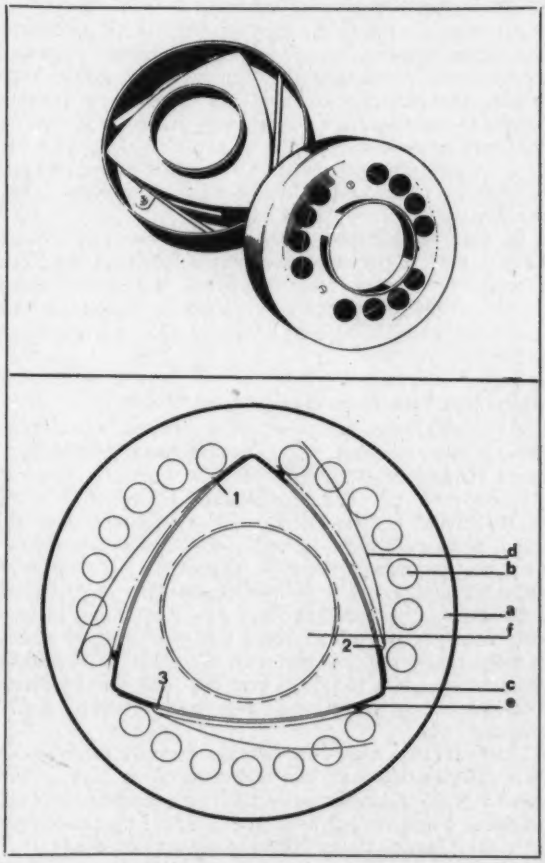
Combustion Control

Any coal, gas or oil burning heater requires a chimney to induce the necessary draught and remove the flue gases. This draught is influenced by the height of the chimney and by the temperature of the gases. An efficient regulator should keep the chimney draught at a constant strength irrespective of outside environments.

The best and most reliable regulator is one fitted to control the air entering the combustion space. The Inal-Air-Control developed by N.V. Inalfa Venray, of Holland, consists of two shells forming a box. Inside the box a steel strip is bent to form a triangle which has in its vaultings rectangular openings. Over these slots three plate springs are fitted, each having a different curvature.

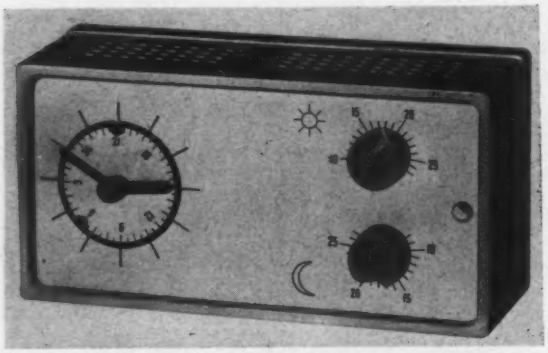
The chimney draught causes the air to enter by holes *b* in the front cover *a*, and then pass through the rectangular slots *1*, *2* and *3* in shell *c* and duct *f* to the combustion chamber. The stiffness of the plate springs *d* has been chosen so that a pressure greater than 1½ mm. of water tends to move them to a closed position on the stops *e*. In this position, only a narrow slot is available for the air. Higher pressure reduces this slot still further, by pressing the spring blade closer to the shell *c*.

By this method, not only is the draught kept at a constant strength, but any fluctuations are immediately compensated. The device is said to be extremely reliable and to require no maintenance.



Time Thermostat for Oil Heating Systems

The Ramses time-thermostat, developed by Theben-Werk, Paul Schwenk KG, of West Germany, is suitable for oil heating systems, the automatic control unit consisting of a time switch combined with two thermostats. The contact breaks as the temperature rises and reaches the pre-set upper limit, and re-makes when the temperature falls and reaches the pre-set lower limit.



The Ramses is of distinctive contemporary design, and is finished in a pleasing combination of matching colours. Its temperature range is from 8 to 27 deg. C., the dials being also available with a Fahrenheit scale, and the instrument operates from a.c. mains of 220 volts, 50 c/s. The desired temperatures are set by means of two knobs, and a pilot lamp indicates the switching operations of the thermostat.

High-temperature Adhesive

A new high-temperature adhesive, Raiseal 350, which can sustain temperatures up to 540 deg. C., has been developed by Radiation Applications Inc., of the U.S.A. Applications include the protection of electrical components, bonding copper to glass-fibre epoxy laminates, and other laminating processes where high temperature and high electrical resistance are primary requisites. Laminates bonded with Raiseal have shown no subsequent delamination after being dipped in hot solder.

By dip impregnating asbestos components in thinned Raiseal 350 the electrical resistance is increased, and their adhesion to metal surfaces improved. The asbestos pores are then made impervious by joining the two surfaces with unthinned Raiseal 350, which acts as both bonding agent and sealant.

One-shot Fire-retardant Rigid Foam

Combining lower cost with exceptional technical versatility, a new one-shot, rigid, fire-retardant polyurethane called Hetrofoam 250 is reported to be a major advance in the development of rigid foam systems. This material, made by the Durez Plastics Division of the Hooker Chemical Corp., offers a significant saving in cost through the elimination of expensive prepolymer processing of resin with toluene di-isocyanate. It is possible to pour the foam in thick sections without knit lines or air inclusion. In tests with sandwich panels, the foam has demonstrated an extremely rapid and uniform rise. Excellent skin-bonding characteristics to a variety of surfaces, rapid cure, and uniform densities are obtainable even under reduced mould pressures.

The final foam, highly fire-retardant through the inclusion of a chlorine-rich acid, can be produced on high or low capacity foam machines with equal ease and efficiency. Conventional foams require additives to obtain fire-retardance, often with resulting property weakness or added cost.

Physical properties include heat stability at temperatures of beyond 80 deg. C.; a low k factor of 0·11 at 24 deg. C. providing excellent insulation properties together with dimensional stability; and low water absorption and moisture permeability. The new foam is said to be ideally suited for applications in refrigerating appliances and boat construction.

New Miniature Thermostat

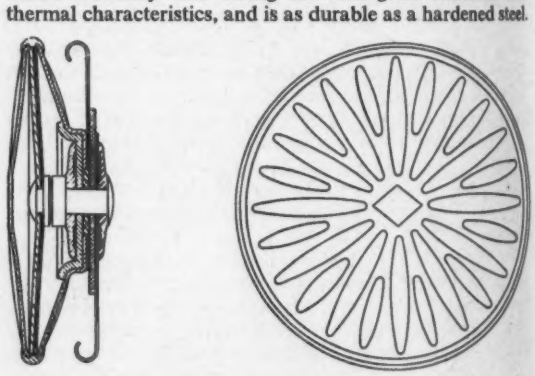
The Paratherm (manufactured by Kontaktwerk Enzberg, of Germany) is a thermostat in the shape and size of a trouser button, with fixed switching temperatures. It has unusually high switching capacity, even on inductive load, and has a relatively high contact pressure. Type V Paratherm is gas-tight, vacuum sealed, and protected against dust and impregnating lacquers, and has an accurate switching temperature.

Three types of action are available, break contact, make contact and changeover contact. Operating temperatures range from 10 to 200°C., and the interval between "operate" and "release" temperatures can be varied as required between 3 and 60°C.

The measuring or switching element of the Paratherm is a circular arched bimetallic disc. It carries at its centre a special hard silver contact having a head and tail of large area giving good contact and heat-transfer. The arched disc is polished and silver plated to ensure fault-free uninterrupted current and heat transfer. The bimetallic switching element is fixed in the folded edge of its metal container. In either position it remains under pressure.

The standard Paratherm has a very durable brass casing which for "make" and "break" switches incorporates one high-capacity back-contact of silver—for changeover switches, two are used. The back contact is always well insulated from the casing, which is conductive and can withstand a pressure of 8½ lb.

For the vacuum-tight armoured container, Paratherm V, the casing consists of homogeneous, gas-tight beryllium-copper sheet radially profiled for stability, and heat-treated before assembly. The casing also has good electrical and thermal characteristics, and is as durable as a hardened steel.



Explosion-proof Paratherm in a pressure-tight container.

It can be exposed to a pressure of 25 atmospheres without affecting its temperature characteristics. This is important when it is inserted in the vacuum-impregnated windings of water, acid and explosion-proof motors. In binding with insulating tape, and during solidification of the insulating materials, as well as in the final drying in the oven, the liquid- and gas-tight Paratherm is exposed to very high pressures. For normal voltages of 6 to 550, this size and shape can always be inserted into the motor winding, while still allowing the arched bimetallic disc sufficient clearance for the necessary contact spacing.

TORSIONAL STRESS IN SHAFTING

Engineering Materials and Design

DATA SHEET No. 70

This nomogram can be used to evaluate the torsional stress in shafting subject to torque loading. The torque relative to a given horsepower transmitted can be calculated as

$$\text{Torque (in.-lb.)} = \frac{63{,}025 \times \text{horsepower}}{\text{r.p.m.}}$$

The polar moment of inertia concerned can be read from the Table for a range of common diameter sizes. For hollow shafting the required polar moment of inertia is obtained by subtracting the equivalent values for the outer and inner diameters, respectively.

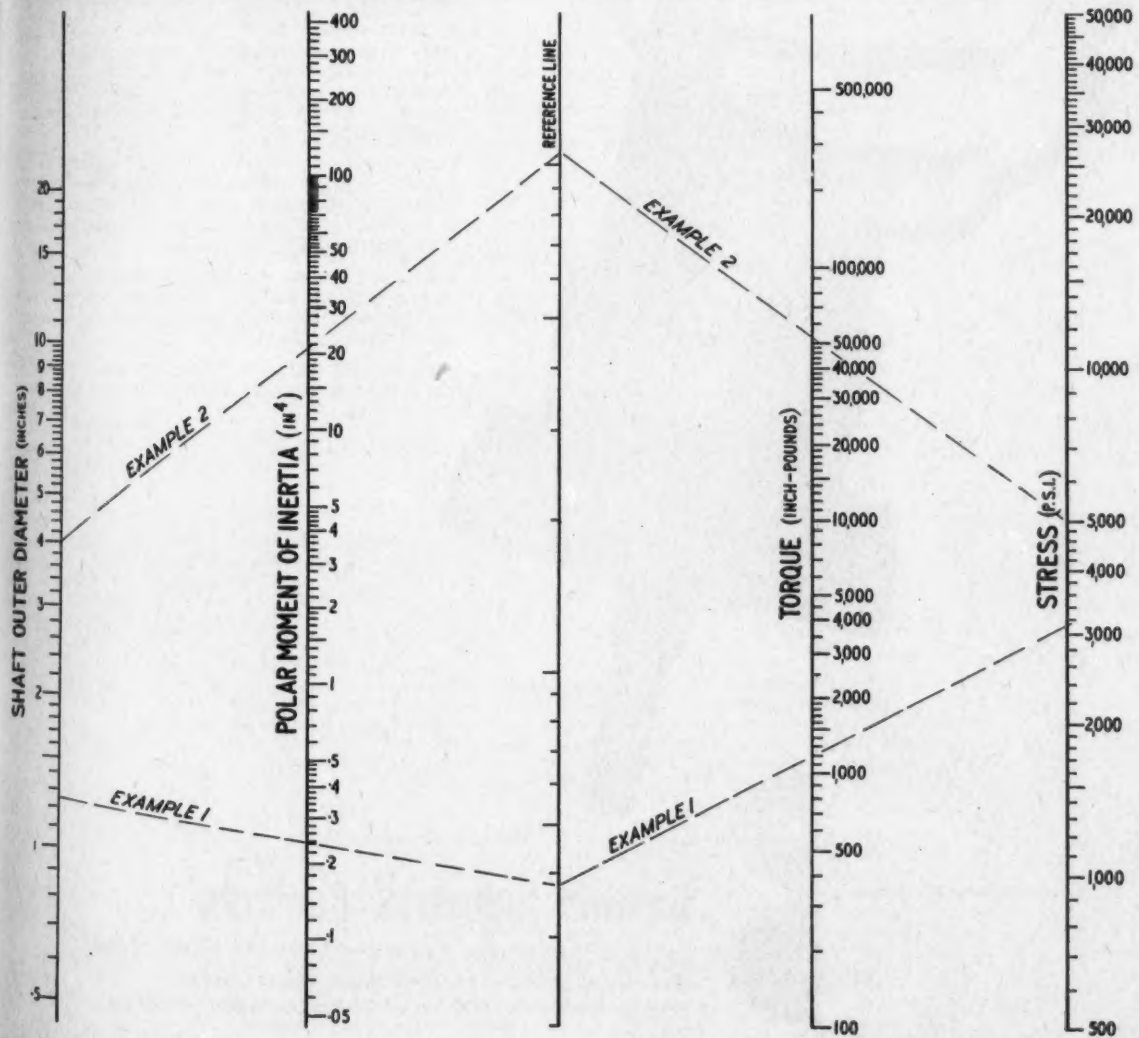
Example 1: Given a 1¼-in. dia. shaft subject to 1,200 in.-lb. torque —to calculate the stress in the shaft. Polar moment of inertia (from Table)=0·24. Connect shaft diameter through polar moment of inertia to reference line. Project from same point on reference line through torque scale value to read stress on right-hand scale. Answer 3,120 p.s.i.

Example 2: Given a hollow shaft of o.d. 4 in. and i.d. 2½ in.—to find the maximum torque that can be transmitted with a maximum permissible material stress of 5,000 p.s.i. From Table, polar moment of inertia at 4 in. dia. minus polar moment of inertia at 2½ in. dia. =25·13 −3·84=21·29. Project from shaft o.d. through 21·29 to reference scale, then across to permissible stress. Read maximum permissible torque. Answer 53,000 in.-lb.

Note: The range of any scale may be extended by factoring, provided the following basic relationship is unaltered:

$$\frac{\text{stress (p.s.i.)}}{\text{torque (in.-lb.)}} = \frac{\text{dia. (in.)}}{\text{polar moment of inertia (in.}^4\text{)}}$$

Diameter (in.)	Polar Moment of Inertia (in.⁴)	Diameter (in.)	Polar Moment of Inertia (in.⁴)
1	0·098	4¾	49·98
1¼	0·24	5	61·36
1½	0·50	5¼	74·58
1¾	0·92	5½	89·84
2	1·57	5¾	107·32
2¼	2·52	6	127·23
2½	3·84	6¼	150·20
2¾	5·61	6½	175·25
3	7·95	7	235·72
3¼	10·95	7½	310·63
3½	14·73	8	402·12
3¾	19·41	8½	512·48
4	25·13	9	644·12
4¼	32·03	9½	799·64
4½	40·26	10	981·75



EMD 7957 for further information

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s/34

POLYPROPYLENE YARN

Engineering Materials and Design
DATA SHEET No. 71

Table 1. Comparison of the general properties of high tenacity filament yarns

Property	Ulstron * Polypropylene	High Tenacity Nylon	High Tenacity Terylene *
Tenacity (g.p.d.) .. .. dry	8 – 9	7·4 – 8·8	6 – 7
.. .. wet	8 – 9	6·0 – 7·9	6 – 7
Extension at break	18 – 22	12 – 20	7 – 15
Initial modulus (g.p.d.)	90	45	130
Moisture regain (%)	0·15	4·2	0·4
Specific gravity	0·91	1·14	1·38

*A product of Imperial Chemical Industries Ltd.

Strength

With a tenacity of approximately 8½ g.p.d. Ulstron polypropylene yarn is in the same strength bracket as type 600 nylon, the high tenacity being obtainable in the finest 190 denier. It loses no strength on wetting, and is the strongest fibre known in the wet state. Tests on twines indicate a slight increase in strength on wetting.

Stretch Properties

The stretch properties of Ulstron are midway between those of Terylene and nylon. Its strength at normal working loads is closer to that of Terylene than nylon, but its extension break is about the same as nylon. This combination is ideal for many applications since high stretch is not usually required at low loads, though it is an advantage when high shock loads are encountered.

Density

The very low specific gravity of 0·91 makes this polypropylene fibre the lightest fibre known. This is not only a frequent operating advantage, but it also has economic advantages, since rope or netting (which is often sold by weight) made from it is much lighter than the equivalent product in other fibres.

Chemical Resistance

The chemical resistance of Ulstron is that of Terylene and nylon combined, as can be seen from Table 2.

Table 2. Comparison of Chemical Resistance

Chemical Conditions	Strength Retained (%)		
	Ulstron Polypropylene	High Tenacity Nylon	High Tenacity Terylene
96% sulphuric at 20°C. for 100 hrs.	100	0	0
34% hydrochloric at 20°C. for 100 hrs.	100	0	89
40% caustic soda at 20°C. for 100 hrs.	90	90	0
100% metacresol at 70°C. for 150 hrs.	100	0	0

Abrasion and Weathering

The abrasion resistance of polypropylene yarn is slightly less than that of nylon. The yarn is completely rot proof and is stabilised to reduce ultra-violet degradation—it is at present considered satisfactory in this respect for cordage, netting and most other applications. Long-term sunlight exposure trials are in progress to determine its performance in applications where sunlight resistance is critical.

Heat Resistance

Ulstron has a lower melting point (165 deg. C.) than both Terylene and nylon, which melt at approximately 265 deg. C., but a higher melting point than high density polythene, which melts at 140 deg. C. Development work is required to determine whether polypropylene yarn will be suitable for the reinforcement of rubber or plastics products such as tyres, belting, hose and coated fabrics. The bonding to rubber and other elastomers may present some difficulty, and the solution to both these problems may well lie in doubling or core-spinning with cotton. High needle temperatures may also limit the fibre's widespread use for sewing threads, as may the present difficulties in dyeing. Although nets can be dyed satisfactorily, sewing threads must withstand dry cleaning and other stringent processes.

New Books

The Technical Illustrator. *By H. Cook (Chapman & Hall—35s.)*

The personal touch of the teacher, which the author has managed to imbue into this handbook, will do much to stimulate the interest and ambition of the budding industrial artist, for whom it is primarily intended.

The rudiments of illustration are quickly discussed and the direction of study applied to practical examples, many of which were selected by the rather novel but sensible method of balloting among students and artists, with the purpose of discovering which specimens they had found most helpful. In order to ensure a correct approach, simple explanations of the functional aspects of the examples chosen are given, and it is a commendable feature that many of the illustrations are relative to one another, thus relieving the student of the necessity to absorb too many engineering technicalities.

Detailed guidance through the various stages of exploded views and cut-away drawings is provided, with timely warnings of the many pitfalls to be encountered particularly when working from orthographic drawings, the misleading characteristics of which are shown graphically. Basic principles of geometric and free-hand drawing are fully discussed, and axis-length ratios lucidly explained, so that the pupil may then progress through the techniques of inkwork and the interesting medium of the scraper board.

Rules designed to assist in the elimination of errors, and the advantageous use of space with the accent on costs, are contained in the later chapters, which also outline the methods used in reproductive processes. The author then continues the teacher-pupil relationship (which is admirably maintained throughout by advising on the equipment, textbooks and materials to be obtained), and concludes by providing the newly-fledged illustrator with an introduction to the type of environment which he may expect to find on his industrial debut.

A. H. Roach

Heat Transfer. *By B. Gebhart (McGraw-Hill—83s. 6d.)*

This is a well written book which avoids the disjointed collection of experimental and analytical data sometimes associated with earlier textbooks on heat transfer. Considerable thought has been given to developing coherent explanations of the various heat transfer processes; these will be appreciated by both post-graduate students and practising engineers.

While not endeavouring to present a vast compilation of new experimental data, the author draws on a lot of recent work and describes new modes of thought applied to solving problems in this field of engineering.

Commencing with a short introduction which briefly describes the elements of the basic processes, chapters are devoted to general conduction and steady state conduction; unsteady-state conduction; thermal-radiation phenomena; and energy exchange by thermal radiation. Further chapters discuss fluid flow processes; forced convection; convection with body forces; heat transfer with liquid vaporization; and vapour condensation. The final chapters cover heat transfer by combined mechanisms, design considerations and experimental analogues. Concluding the book are various appendices on physical properties.

R. W. New

Mechanical Engineering Experimentation. *By G. L. Tuve (McGraw-Hill—62s.)*

The scope of this book is narrower than the title suggests—a more informative description might be "Instrumentation and student experiments in the Fluids and Heat Engines Laboratories". It is intended as a laboratory text and reference book for courses of say the H.N.C. type, and is based on the experiments available in Professor Tuve's laboratory at the Case Institute of Technology. The aim of the experiments is not so much to reinforce basic principles as to train a young engineer to make a competent performance test of a machine or system.

There is a very short section on the planning of a test, the analysis of the readings and the writing of the report. Next comes an excellent section on measuring instruments, with a brief description of most of the instruments a student is likely to use (references to sources of fuller information would be valuable here). This part of the book includes a short, clear introduction to the basic principles of control systems. The main bulk of the book, roughly two-thirds, is devoted to a description of the experiments, seventy-six in all, ranging from the calibration of pressure gauges to the performance tests of I.C. engines.

The style is clear and practical, the illustrations good, and the lay-out and production are of the high standard one expects from this publisher. The object of this book is admirable; instruction in the laboratory tends to be much more haphazard than in the classroom, and a reference text is most helpful. The difficulty in producing a satisfactory text is that the experiments available in different laboratories inevitably vary, and a student who buys this rather expensive book must be prepared to find that much of it will not be directly relevant to his own work. The instructor, realising that the aim is not to present any novel experiments, will find this book an excellent model of laboratory instruction planned as a progressive coherent system.

A. Ormerod

Elementary Machine-shop Inspection. *By R. C. Tatlow (Blackie & Son Ltd.—9s.*

There are numerous books on metrology, but as yet very few on machine-shop inspection; this handy volume is a good attempt to fill the gap. It is simple in layout and includes many clear diagrams, being bound with limp covers to provide a book suitable for reference during the day's work.

The first few chapters provide an introduction to the purpose and application of simple inspection, drawing and the concept of limits. The fourth chapter deals with the first actual inspection technique—slip gauges—and this seems to be rather like jumping in at the deep end, when learning: surely slip gauges is hardly a suitable starting point! Taylors Principle is dealt with in chapter eight, and is an interesting feature which may not be entirely appreciated by a comparative novice. The remainder of the book is devoted to the use of the standard inspection tools, including micrometers, verniers, etc.

A complete study of the inspection problems involved in two typical jobs is given in the final chapter. This venture into the practical aspects of inspection deserves to be a success, and every practising engineer should derive benefit from a careful study of Mr. Tatlow's commendable effort.

R. H. Pritchard

OTHER BOOKS RECEIVED

Financing your Business. *(The Engineering Industries Association—5s.)*

A simplified explanation of the various types of finance which may be used in the profitable development of a business.

Reinforced Plastics for Rockets & Aircraft. *(A.S.T.M. special technical publication No. 279 — $5.50 to non-members, $4.40 members.)*

Contains papers relating to reinforced plastics and thermal ablation presented at 1959 symposium.

Adhesion & Adhesives *(A.S.T.M. special technical publication No. 271—$2.25 to non-members, $1.80 to members.)*

Contains five papers evaluating adhesives and tests including the use of ceramic adhesive for stainless steel.

Building Constructions. *(A.S.T.M. special technical publication No. 282 — $3.50 to non-members, $2.80 to members.)*

Contains useful information on screw holding ability of timbers, and deflection limitations in timber design.

A.S.T.M. Standards on Copper & Copper Alloys. *(18th Edition, 1960—$9.25 to non-members, $7.40 members.)*

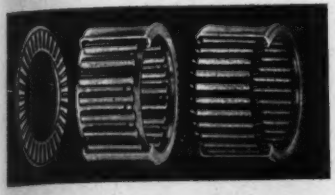
A.S.T.M. supplements (1960) Part 1, ferrous metals; Part 2, non-ferrous metals and electronic materials; Part 3, methods of testing metals.

What to see at the Engineering Materials and Design Exhibition

Earls Court, November 13-18, 1961

Needle and Roller Bearings

Exhibits by *The Torrington Co. Ltd.* will include a comprehensive range of drawn cup needle and roller bearings (full complement and caged), with a selection of needle thrust bearings, loose rollers and cam followers. Engineers will be on



the stand to explain how these bearings have contributed to the success of a wide variety of products from business machines to earth-moving equipment, and to discuss suitable applications.

Oil Sealing

Charles Weston & Co. Ltd. will be showing a range of their oil sealing components, the principal types being the Weston oil seals with leather or synthetic rubber wiping lips. All seals of this range will be shown, including single, double, tandem and external types. The Weston split seals for heavy-duty service, such as in rolling mills, oil engines and gearboxes, are also being exhibited. These also have marine applications, one example being in stern tubes. All wearing parts can be renewed.

Other items will include O rings to BS specifications; synthetic rubber mouldings to customers' own specifications; Impax mechanical seals for applications where optimum performance is required; and Dupax water pump seals.

Resin Applications

United Coke & Chemicals Co. Ltd. will be showing the Orkot resin-bonded fabric-bearing materials in the form of rolling mill bearings, bushes, rollers and roll coverings, and laminated sheet. Available for interested engineers will be small samples of Orkot bushes and grade TL laminates for evaluation purposes.

Also on display will be examples of the many uses of Orkast resins, showing their suitability for intricate reinforced-plastics moulding, etc. Models will include: a 5×5×5-ft. reinforced container; a reinforced-plastics vehicle cab; tank sections, a p.v.c.-lined tank; an exhaust stack; and examples of repair and construction kits.

Examples will be shown of applications of the various special pitches manufactured by the firm for pitch-epoxy resins and pitch-polyurethane rigid foams.

Design Consultants

The stand of *E. G. Irwin & Partners Ltd.* will feature a series of photographs illustrating the wide range and diverse nature of the projects encountered by the company as design, development and consulting engineers. Such is the nature of the work that it is not possible to show adequately by illustrations the skill and experience of the teams within the organisation. Visitors to the exhibition are cordially invited to this stand to discuss their projects with executive engineers of the company.

Slewing Rings

Priestman Brothers Ltd. are showing only one of their products, namely the patent Priestman cross roll bearing slewing ring. The tapered rollers have a constant rolling speed which prevents skidding under load, and being pre-loaded they eliminate the need for initial clearances. This ensures operational rigidity which eliminates rocking between superstructure and base. No centre pin is required, thus a larger area is left unobstructed for control gear. The bearings are obtainable in diameters ranging from 1 ft. 10 in. to 8 ft., and are particularly suitable where vibration or hammering is present.

Ceramics

Lodge Plugs Ltd. will be showing examples of the many applications of Sintox, including thread guides, eyelets and tension devices used in the textile industry. The properties of this ceramic make it particularly attractive to the engineer requiring hardness, abrasion resistance and immunity from chemical corrosion. Sintox can be used for cutting-tool tips, and as dies for the cold drawing of metal tubes and bars. Its insulating properties make it very suitable for use in the electrical industries, and a technique is now available whereby it may be brazed direct to metals. Its heat resistance enables it to be used for rocket nose cones and nozzles in high-temperature burners, as well as in nuclear applications.

By a special process known as Lodge Ceracote, alumina and similar oxides can be sprayed on to metals and other materials. After treatment the coating, which is of controlled thickness and within the range 0·005 to 0·020 in., is quite flexible and capable of conforming to the thermal movements of the base material.

Also available are a high-purity machinable alumina which does not require firing after machining, and a conducting ceramic which has the mechanical and thermal properties of Sintox but which is capable of acting as a conductor.

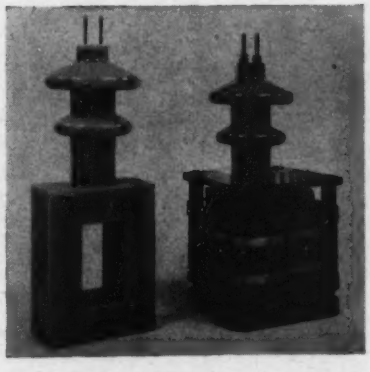
Laminated Plastics

Tufnol Ltd. will be showing examples of Tufnol industrial laminated plastics material in the form of sheets, tubes, rods, angles and channels. Display panels of machined and moulded components will illustrate the versatility in application of this material.

Tufnol is said to be eminently suitable for a wide range of components, including gears, bearings, jigs, electrical insulating parts, marine fittings, motor-car parts, aircraft components, and chemical and nuclear plant equipment. Technical engineers will be available on this stand to advise potential users.

Design Studies at U.K.A.E.A.

The *U.K. Atomic Energy Authority* stand will consist of some sixteen items showing, by photographs, models and actual equipment, the work of the various U.K.A.E.A. establishments. The subjects of study include beryllium, which apart from its main application in the nuclear field, is now receiving increased attention for evaluation as a structural material. There will be a demonstration of spark machining of narrow slots, and also of a highly effective method whereby a vacuum or partial vacuum can be applied to a moving mechanism. Other subjects being studied include: an ultrasonic technique for testing the bond of roll-welded alu-



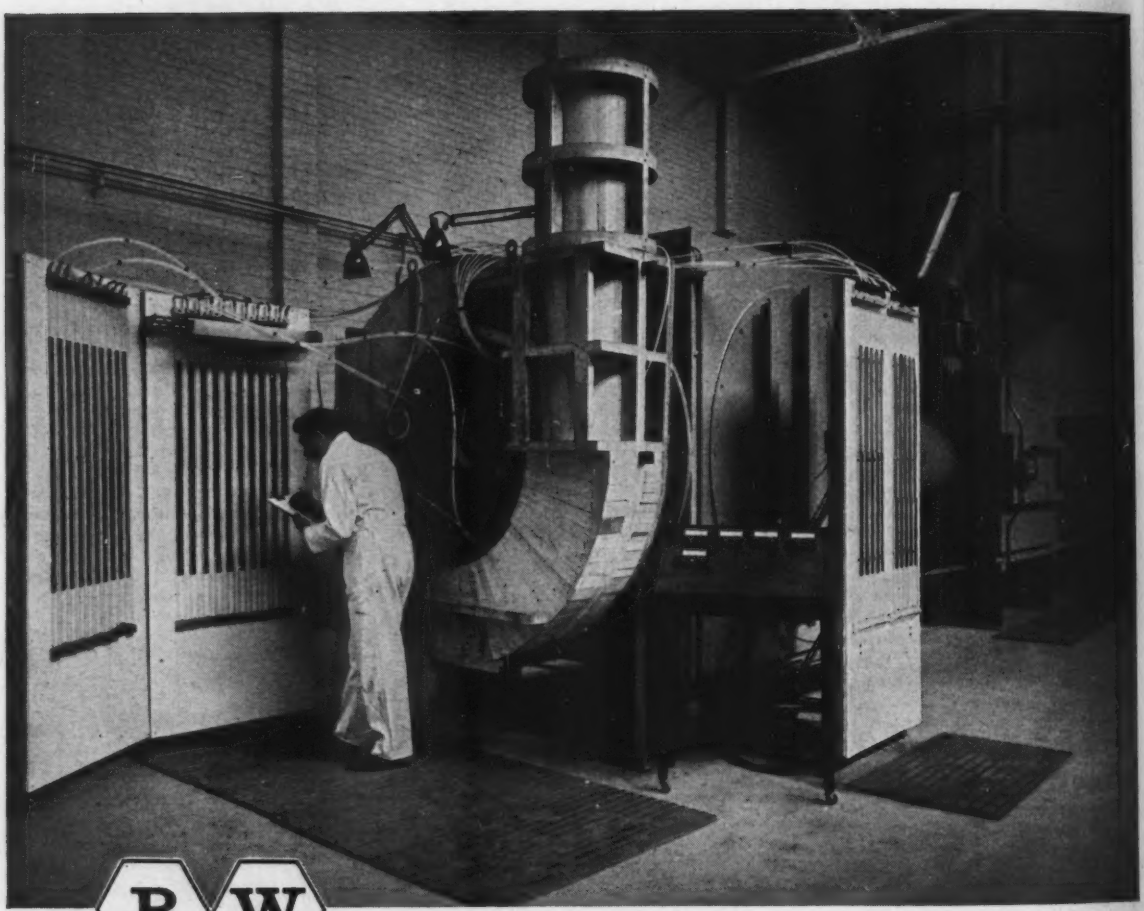
minium-clad cadmium plate; the avoidance of brittle fracture and crack propagation in reactor pressure vessels; the production, between matched metal moulds, of a laminated plastic envelope said to be one of the largest resin-glass laminate made to engineering tolerances; the development of high-voltage isolation transformers for use in pressure vessels where oil-filled components cannot be used; and quartz springs which have important applications in the measurement of small changes of weight in closed systems.

EMD 7960 for further information

You'll get no stock answers here!

On the Development side at Richardsons Westgarth we work from principle, not precept, and use a conventional solution to a problem only when we are sure it is the economic one.

It is this outlook that has enabled us to provide new answers to many problems in mechanical engineering, from turbo-machinery to sea-water distillation plant.



In the Aerodynamics Laboratory of the Richardsons Westgarth Group, an engineer tests an air flow model of the outlet diffuser and volute assembly for a high-speed centrifugal compressor. These volutes and diffusers will be used on a number of gas turbo-compressors at present being manufactured for a well-known Oil Company.

RICHARDSONS, WESTGARTH & CO. LTD.

The Controlling Company of the Richardsons Westgarth Group, Wallsend, Northumberland and at 58 Victoria Street, London, S.W.1. 59 Mosley Street, Manchester. 75 Buchanan Street, Glasgow.

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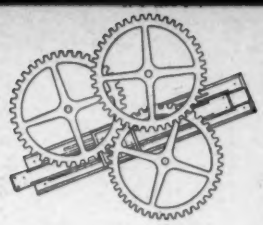
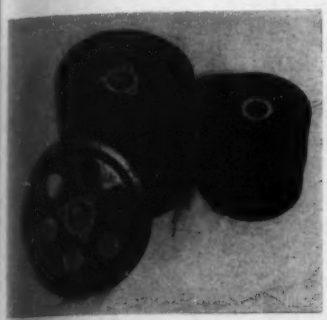


Plastic-coated Components

New exhibits shown by *Plastic Coatings Ltd.*, of Guildford, will include what is believed to be the largest dip-moulded bellows ever produced in this country. This is the ideal method of making large, flexible bellows for a very low tool cost. Also on show will be a nylon-coated filter press plate, an interesting example of where a nylon coat obviated the use of stainless steel, at a fraction of the cost, and at the same time gave an excellent release and easily cleaned surface. These filters are being currently used in viscose and chemical works.



The accompanying photograph shows a group of control pulley wheels, used on the De Havilland Comet, which have a 0·025 in. thick nylon coating. This coating prevents chafing of the pulley wheel by the metal cable, and trebles its life, thus reducing servicing and replacements.

High-nickel Alloys

The *Henry Wiggin & Co. Ltd.* stand will not contain any specific exhibits as such, but will feature a comprehensive range of technical publications on Wiggin high-nickel alloys. Technical service and sales staff will be on duty to help with any problem on the use of these materials.

P.v.c. Pipes and Coatings

On the stand of the *Distillers Plastics Group*, British Geon will feature as the centrepiece a section devoted to high-impact p.v.c. pipe, and particularly a test rig displaying pipe made of high-temperature resistant compound (for withstanding temperatures of up to 95 deg. C.). Also featured will be samples of standard pipe and fittings in Geon high-impact p.v.c., and pipe will be seen undergoing tests in a working testing station.

Another display will show how dip-coating in p.v.c. paste can give permanent maintenance-free protection to a wide range of metal parts, ranging from pump castings to fencing panels. This method of protecting metal from corrosion and abrasion has recently become increasingly popular, as it eliminates costly handwork which is otherwise necessary. Elsewhere on the stand, visitors may see a type of oil-resistant glove made from Hycar nitrile latex; pit props protected with a sheathing of p.v.c.; cable sheathing able to withstand temperatures up to 105 deg. C.; and a number of other exhibits.

Vacuum Melting Plant

A vacuum-melting plant will be the highlight of the stand featuring products from *Thos. Firth & John Brown Ltd.* Vacuum re-melted steel made by the consumable-arc process is available from Firth Brown in ingots from 12 to 26 in. dia. The process is used to still further refine steel made by the normal electric steelmaking procedure, and is claimed to produce the cleanest steels commercially available, and to offer advantages in freedom from segregation.

On the opposite corner of the stand will be a test tank for ultrasonic inspection by the immersion method, containing a drop-stamped gas-turbine disc (produced by Firth-Derihon Stampings Ltd.) machined with a rectangular profile to facilitate examination, and provided with an artificial defect.

Demonstrated by means of photographs will be gap-scanning equipment for the semi-automatic examination of large rotor forgings weighing up to 70 tons and up to 46 ft. long. The forging is rotated and the probe holder traversed axially, the speeds being so adjusted that complete coverage is obtained.

Among other exhibits on the Firth Brown stand will be examples of (1) nitriding steels, used in the manufacture of such items as plastics extrusions, glass bulbs and piano frames; (2) developments in the production of turbine wheels; and (3) steels of hardness that is increased with temperature demands.

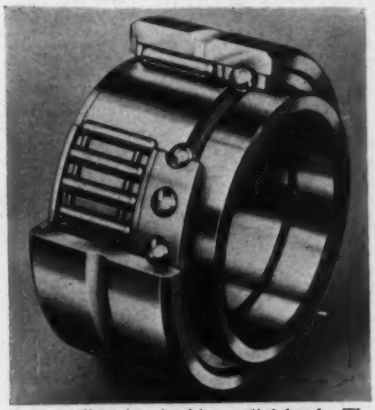
Needle Bearings

Included in the range of various types of needle bearings to be shown by *INA Needle Bearings Ltd.* are needle cages in strip form as applied for linear motion. Fitting these flat cages prevents the "slip-stick" phenomenon, and ensures the easy linear motion which is often required for slide-ways, guide rails and other similar applications. The flat cages are made of plastics, and the needle rollers are 0 to −2 μ (0-0·00008 in.); they are retained and located individually.

The adjustable needle bearing is a new type of high-precision rolling bearing which allows sensitive setting of the radial play during operation. This type of bearing is being used successfully for work spindles, index plates, etc., where a high degree of accuracy is essential. The adjustment is obtained by axial clamping of the profiled outer race, which, at the same time, ensures centering and a proper fit in the housing.

All INA combined needle thrust bearings are combinations of needle bearings with ball or cylindrical roller bearings. There are three different types, distinguished by the thrust bearing used with the needle bearing. They are specially suited for applications in gearboxes, and in machine-tool designs for bore spindles, centering spindles, worm shafts, and spindles of thread cutting heads.

Type NKX, a combined needle thrust ball-bearing, can take high thrust loads



in one direction besides radial loads. The combined needle thrust roller bearing is similar in design to the NKX type, but incorporates a roller thrust bearing, giving a much higher thrust capacity.

By combining a needle bearing with an angular contact ball-bearing, a rolling bearing has been produced capable of taking up high radial loads and small thrust loads using a minimum amount of space. The accompanying illustration shows a double thrust bearing taking axial loads in both directions. A similar version of this bearing is produced having facilities to cater for axial loads in one direction only.

Precision Steel Castings

On the stand of *Hadfields Ltd.* will be a selection of precision castings covering the requirements of a wide field of industry, and ranging in weight from a few ounces up to 45 lb. Shell-moulded castings will include the Esco box-type points which have been designed to replace the old-type solid teeth used on earth-moving equipment, while a coating of interest to civil engineers will be the ERA manganese steel expansion joint to be used on one of the bridges of a new motorway.

Photographs of the new Gauldie hydraulic crusher will be seen, together with a working model of the hydraulic system; this crusher is said to have many advantages over the conventional jaw breaker. Other exhibits will include various types of steel castings, and a range of De Zurik-type valves.

EMD 7961 for further information

poles apart

THE SECOND Engineering Materials and Design EXHIBITION and CONFERENCE
EARLS COURT 13th-18th NOVEMBER 1961

His ability to compete is taking a beating and the truth of $P = \pi^2 EI/4l^2$ will soon bring him to earth with a bump. If only he'd remembered to relate 'crippling' load with length, modulus and cross section . . . He'd have been 'at one' with designers who choose versatile magnesium for struts and columns.

The lightest structural metal, magnesium offers all the strength, stiffness and resilience, an ability to beat competition wherever it is used.

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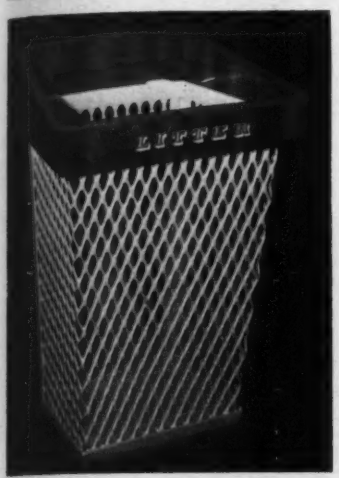
Magnesium Elektron, Inc., New York 20, USA

Expanded Metal

Expanded metal in sheets and manufactured articles are to be exhibited by *The Expanded Metal Co. Ltd.* These items will include expanded steel meshes in industrial finishes, including coloured plastics coatings; expanded aluminium plain and patterned meshes in colour anodized finishes; expanded plastics, copper, brass, stainless steels and heat-resisting steels; and Minimesh non-woven fine gauze.



Fabricated articles will include a walkway, electrical cable trays and Minimesh cylinders. The accompanying photograph shows a typical application of plastics-coated expanded metal. Permalock demountable partitions for factories and offices will also be shown.

The Sheepbridge Group

Four member companies of the Sheepbridge Engineering Group will be exhibiting: *Sintered Products Ltd., Sheepbridge Stokes Ltd., Sheepbridge Equipment Ltd.*, and *Sheepbridge Alloy Castings Ltd.*

Sintered Products Ltd. will be displaying processing techniques used in the production of Durasint structural parts, which are engineered to a high degree of accuracy in iron, iron alloys, nickel steel, stainless steel and bronze. The properties inherent in these sintered parts enable design engineers to work to a much higher level of precision, and therefore build in greater value, better performance and higher quality in a variety of applications. Durasint friction materials, for brake and clutch applications, offer outstanding friction stability at high operating temperatures.

Porosint bronze, another product of this company, is a sintered porous metal which has been developed to meet the demand for a filter material possessing controlled porosity together with high mechanical strength. This material can be moulded to a wide variety of shapes and micron ratings to suit individual applications.

Porosint Rigimesh is a porous sintered mesh normally manufactured in stainless steel, though it is also available in Monel, Nimonic 75, Nichrome, bronze and nickel. This material is produced in sheet form, and it is possible to fabricate filter elements from it to almost any shape by normal metal-working and welding techniques and to give porosity ratings from 2 to 100 microns.

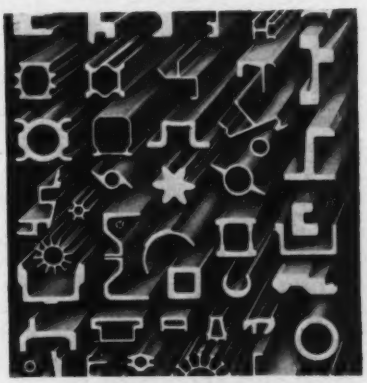
First in the field with the centrifugal casting technique, Sheepbridge Stokes Ltd. will be showing an interesting selection of cylinder liners. Various types of rollers, including induction-hardened units, will also be displayed. This company has recently installed up-to-date equipment for the production of induction-hardened cylinder liners, and it is now possible for designers to specify surface-hardened liners where they are needed, and not, as hitherto, only where price considerations permit.

The bi-metals process, which has been pioneered in this country by Sheepbridge Alloy Castings Ltd., involves the bonding of two metals in one casting. This makes possible the economic utilisation of special metals—for example, the lining of special mild steel alloy tubes with stainless steel for the handling of corrosive liquors. Bi-metals castings and long centrifugally-cast tubes will be displayed, together with a wide range of industrial components in special steel and alloys.

Sheepbridge Equipment Ltd. (Foundry Division) produce closely controlled castings of all grades to BS specifications. Particular emphasis in the exhibits will be given to castings resistant to abrasion. A new and important development in the production of large grinding balls will be included, together with a range of ordinary and corrosion-resistant castings.

Extruded Steel Sections

Alexander Marcar and Co. Ltd. will be displaying a comprehensive range of extruded steel sections produced by Schwerter Profileisenwalzwerk A.G., of Germany.



Also on show will be some of the more recent interesting and difficult extrusions which have been produced, particularly in the larger sizes. In addition a large number of samples from the range of British-made extrusions will be displayed. The applications for these steel extrusions range from heavy engineering and ship-building to light and precision engineering. The accompanying photograph shows a representative selection of extruded sections.

Ceramics

Royal Worcester Industrial Ceramics Ltd. will be displaying an array of Regalox components including insulators suitable for high- and low-temperature metallizing, pump impellers, seatings, plungers and

step cones as used in the wire industry. Also displayed will be guides as used in the man-made fibre and wire industries. Flow-meter floats will also be shown. Many of these components are shown in accompanying photograph.

Range of Castings

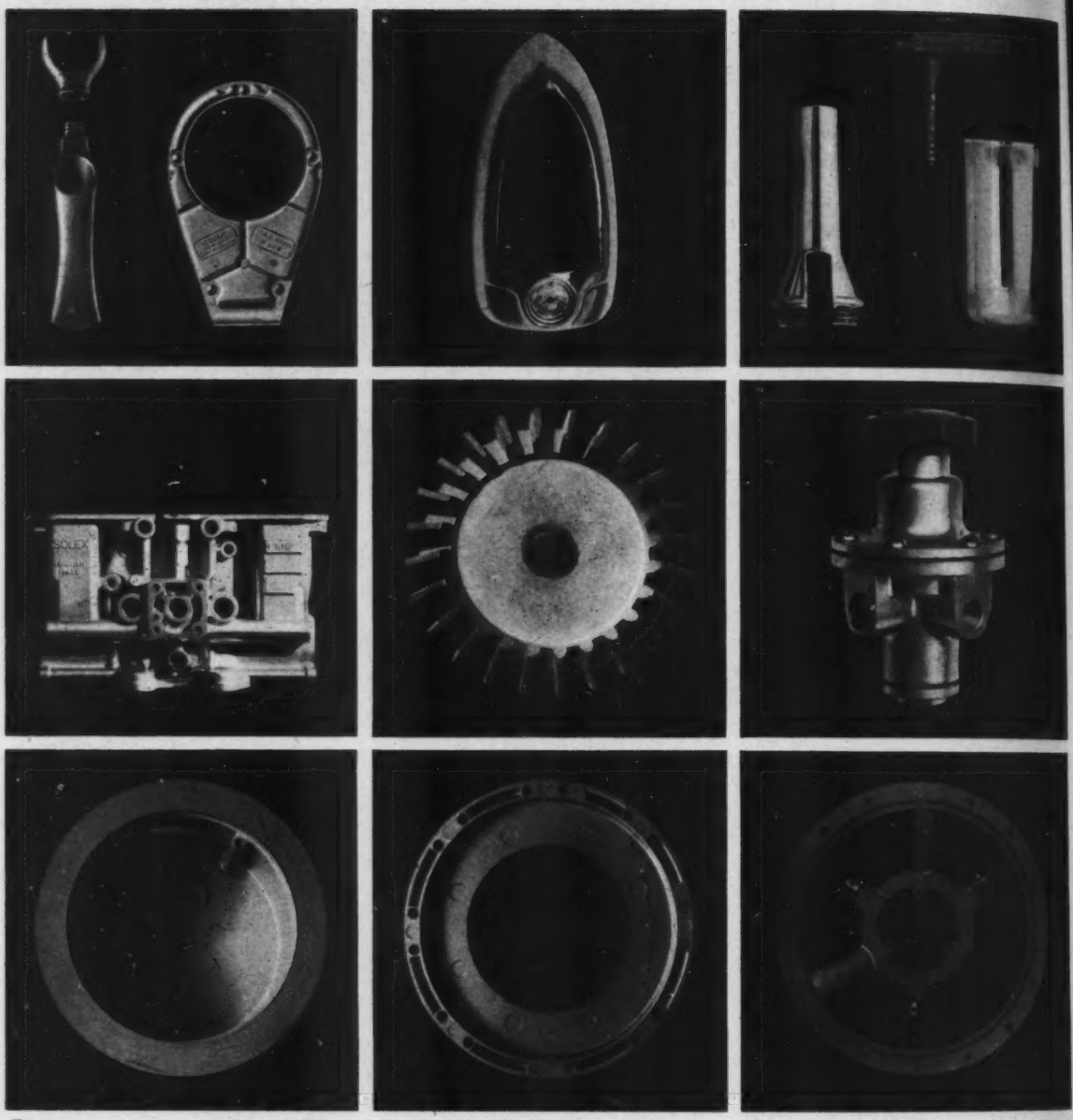
The exhibit arranged by *Universal Casting Developments Ltd.* will include precision wood, plastics and metal pattern equipment, and non-ferrous castings. A relatively new product from this company is Frontier 40-E alloy to DTD 5008-40-E, and the exhibit will show its remarkable strength and machinability—this alloy has a tensile strength of about 16 t.s.i.

Other aspects dealt with on the stand will be glass-fibre lay-ups; spotting frames; vacuum forming moulds; and precision wood models for car body styling.

Design and Materials Research

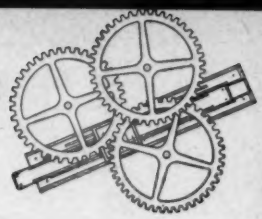
Research on the efficient use of materials and the provision of design data for a wide range of machines and engineering components will form a large part of the displays provided by the *National Engineering Laboratory*, of East Kilbride, on behalf of the D.S.I.R.

The exhibits will demonstrate how to: (1) design pin-joints for maximum fatigue strength; (2) design oil tanks to improve the performance of oil hydraulic circuits; (3) reduce noise and pressure pulsations in hydraulic circuits; (4) extend ball-bearing life by delaying the onset of pitting; (5) reduce friction by using air-lubricated bearings; (6) use computers to design heat exchangers; and (7) determine stresses in complicated sections, using photo-elastic studies.



Come and talk about zinc alloy die castings on Stand A8 at the Engineering Materials & Design Exhibition, Earls Court, 13th to 18th November

The die castings shown above are, top row: table coffee maker, rear light housing, gas lighter. Middle row: carburettor body, twin gear, compressed air valve. Bottom row: pressure gauge, gramophone turntable, and loudspeaker chassis. The ZADCA stand, just by the entrance in Hall D, will display a variety of pressure die castings, and staff from member firms will be there to give technical information on applications and design. ZADCA publications will be available on request. For further information write or telephone to: Zinc Alloy Die Casters Association, 34, Berkeley Square London W1. Telephone: Grosvenor 6636



Silicone Rubbers

A selection of the variety of applications for silicone rubbers will be featured on the stand of the Nobel division of *Imperial Chemical Industries Ltd.* These will include Silcoset room-temperature-curing silicone rubbers, which are being used for: potting and encapsulating electrical and electronic equipment; making flexible moulds for casting epoxy resins;

coating conveyor belting to provide a stick-free surface; and sealing and caulking (see illustration).

A new system of over twenty pigment dispersions for colouring silicone rubbers is to be introduced under the name of Silcolor. Pigmentation in this way is said to be simple, clean, convenient and extremely efficient. Pigmented silicone rubbers and pastes are used in the colour coding of sleevings, tapes, cables, etc., and some of these products will be shown.

Also featured will be the Silcolapse anti-foam agents used to suppress foaming in many industrial processes, and silicone rubbers and resin/glass laminates for electrical insulation.

Bronze and Brass Castings

The Eyre Smelting Co. Ltd. stand will show, by means of casting exhibits, the need which bronze and brass castings fill in all parts of industry, and how, by consulting with the founder as to right metal, right design and right casting method, the designer and engineer can obtain the best results.

A feature will be made of the new A.B.B.F. castings handbook, which gives the designer a guide to alloy selection, mechanical properties and casting methods, as well as alloy specifications. In addition, the new BS 1400:1961 will be featured, and also ingots and castings made from the modern copper-alloy castings given in this new specification.

Aluminium Alloy Ball-bearings

Roballo Engineering Co. Ltd. are exhibiting for the first time one of their high-strength aluminium alloy ball-bearings, cut away to show the steel wire races. These units are fitted in military radar installations; missile launchers and gun turrets, where weight saving is important; the largest unit so far supplied is 90 in. dia.

A typical crane-slewing ring 5 ft. in diameter is to be shown, with the three parts exploded to show the construction. Special designs of ball and roller bearings, from 2 to 24 ft. dia., and some of the new and original machines in which they are fitted are to be shown in photographs.

Of particular interest will be a bearing 6 ft. in dia. supplied for a 70-ft. dia. fan for a large forced draught cooling tower, the gear of which transmits 800 h.p. at 76 r.p.m.

Wood Fibre Mouldings

Some indication of the wide range of application for compressed wood fibre mouldings will be given by exhibits on the stand of *Prestfibre Ltd.* Shown for the first time will be two new motor-car facia top panels, which will be seen as raw mouldings and as finished products. As well as providing a good quality finish to the inside of the car, these panels are an added safety feature in the event of an accident in that they are capable of withstanding a certain amount of shock before collapsing, at which time they do not leave sharp jagged edges. Also to be shown is a new motor-car gearbox cover and a parcel tray.

Anti-corrosion Coatings

Coating Contractors Ltd. apply on site and in their plant at Buckingham a wide range of high build anti-corrosive coatings, both elastomeric and hard in type. The majority of these coatings are from the Adcora range made by their parent company, E. & F. Richardson Ltd., and include Neoprene, Hypalon, Viton, coal tar/epoxy, phenolic epoxy, solventless epoxide, and polyurethane formulations. Both the coatings and the application service will be demonstrated by photographs and physical exhibits, showing the methods adopted for the protective coating of small- and large-bore pipework, valves, pumps, fans, ductwork, tanks, etc.

In the accompanying illustration is a nacelle fairing, showing a multi-step etch employing Neoprene Adcora.

Steel and Titanium Founding

Samuel Osborn & Co. Ltd. will be exhibiting a number of products relative to their business as fine steel makers, steel founders and engineers' toolmakers. These products will include steel castings made by the precision methods of shell moulding. Osborn Shaw & Osborn CO_2 block processes; extruded steel sections; special corrosion- and heat-resisting alloys; and titanium parts. These products find wide application in many varied industries.

Felts and Foams

Cooper & Co. (Birmingham) Ltd. are manufacturers of industrial felts and polyurethane plastics foams (polyester and polyether). The felts and foams for all industrial uses are in the form of washers, pads, strips, gaskets, sheets and rolls, and may be used in products for widely differing applications, for instance, seals, dust excluders, filters, wicks, wipers, spacers and sound-deadening masks. All these will be exhibited, and also on show will be felt bobs, wheels, belts, cones, discs and calico mops for polishing purposes.

The Croid-Cooper method of machinery installation using Cooper's MG grade felt and Croid No. 65 machine fixing glue for the installation of all types of machine tools, plant and machinery, is also being demonstrated.

Iron and Steel Castings

Lloyds (Burton) Ltd. are manufacturers of a wide range of compositions including high-duty irons, spheroidal graphite irons, manganese steel and a range of alloy steels up to 20 tons in weight. Their exhibition, however, will particularly feature those products manufactured in association with the American Brake Shoe Co.

Products which will be specially featured are precision-cast tyre moulds in alloys of special composition, and centrifugal-cast tubes in a wide range of stainless and heat-resisting alloys. Fabrication facilities exist for building these tubes up into finished products which include assemblies for heat-treatment furnaces and roller hearths for continuous furnaces. The exhibit will also feature complete tubes for hydrogen reformer furnaces, and heater coils in austenitic steels for high-temperature pyrolysis.

Several types of link belt and chain conveyors for high-temperature furnaces will be shown, and also the latest alloy for service at high temperatures, Supertherm. This alloy has measurable hot strength up to at least 1,260 deg. C., and is considerably stronger than the more widely used alloys at temperatures lower than this. It can be produced as static and centrifugal castings, and welded assemblies can also be produced. Creep and stress rupture information on this alloy is now available.

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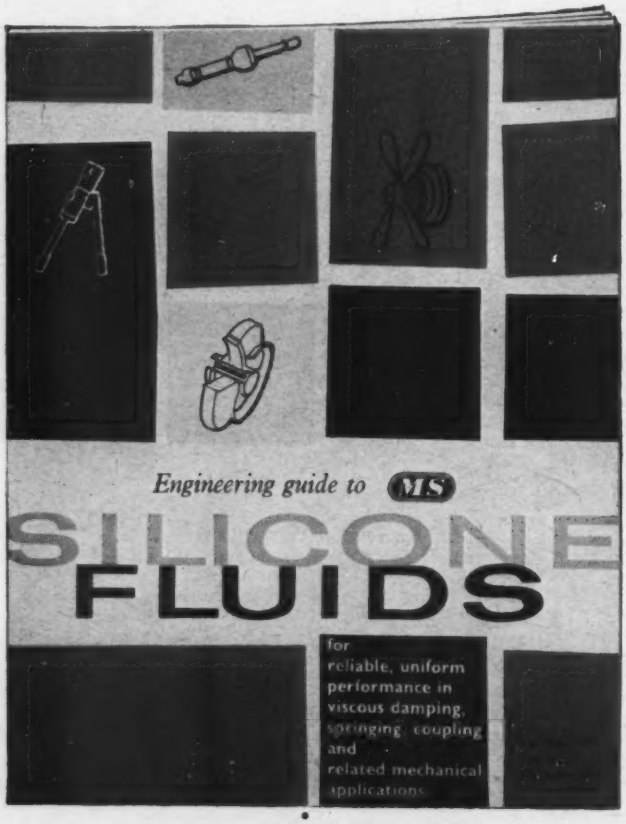
If your requirement is more for silicone lubricants and greases then 'Silicone Lubricating Fluids & Greases' (G 14) *is the publication for you.*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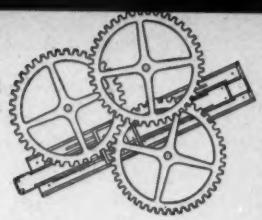


Precision Castings

P.I. Castings (Altrincham) Ltd. will show a range of exhibits typifying the wide diversity of application for their investment castings. Particularly noteworthy is the way in which the flexibility in design permitted by the Picast process has been used to achieve the optimum combination of lightness and strength in the stainless

steel parts used on a high-altitude flying helmet (illustrated here undergoing test), and emphasis is laid on the high resultant saving in machining costs.

This aspect is similarly demonstrated in totally different markets by the large number of Picast components in the vending machine mechanism, and the vital parts of the knotting machanism for an agricultural baler. The wide range of mechanical properties offered in an almost unlimited range of alloy steels is typified by the improved performance obtained from the jaws of a patented self-centring chuck, and the longer life of poodle clipper blades.

As further examples of the many industries now finding advantages in using Picastings, the lever fork on a pair of riveting pliers, and the aluminium alloy components in the methanometer governer, respectively show the economical advantages and reliability inherent in these castings.

In an endeavour to further designers' appreciation of the facilities offered by their process, P.I. Castings are also showing cut-away models illustrating the stage-by-stage progress of the manufacture of a typical casting.

Iron Castings

John Harper & Co. Ltd. will be showing a wide range of castings in grey cast iron, Meehanite and s.g. iron. These will be displayed to show the different applications of each, and how the choice of material is related to the design of the part to best suit its service conditions and economy of manufacture. Castings for pressure tightness, wear resistance, impact resistance, accuracy, machinability and strength will be shown. Special attention will be drawn to the principles of casting design to obtain maximum benefit from the process and materials. Also featured will be examples of cast-to-form tool work, and processed castings.

Asbestos Insulation

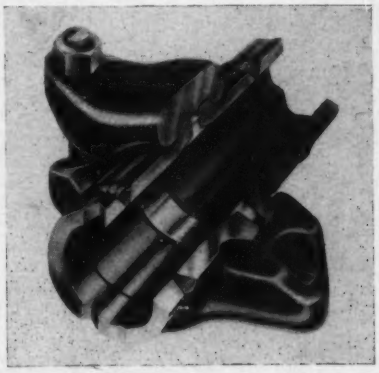
How to save 40% of heating costs by insulating with asbestos sheet will be demonstrated on the stand of *Marinite Ltd.* Two working models of industrial plating and degreasing tanks are to be shown, each with identical gas heating controlled by a thermostat; one is insulated with asbestos, the other has no insulation, and visitors will be able to observe the heating requirements of each.

Other exhibits on the stand will be a catering oven finished with stove-enamelled Marinite, a banana-ripening room heater made of Marinite, and several ovens and other heating devices embodying this material.

Pipe Connectors

Ruston and Hornsby Ltd. will be showing a 30-in. Ruston-Grayloc high-pressure pipe connection, and also one of 2 in. nominal bore connected to a demonstration pump operating at 10,000 p.s.i. A collection of Ruston-Grayloc applications in graphical form will be of particular interest to designers.

Other exhibits will include a Ruston high-efficiency turbo expander, for use in cryogenic applications and in chemical processes where temperature reduction is



required, and a model of a Ruston TA industrial gas turbine driving a crude oil pump of 90,000 barrels per day capacity.

Nylon

Polypenco Ltd. are to exhibit a range of high-grade plastics materials for specific applications in all forms of industrial engineering. For the first time, massive nylon shapes for heavy engineering applications are to be shown, as well as high-pressure nylon hose and pressed and sintered parts in special nylon and p.t.f.e.-based formulations.

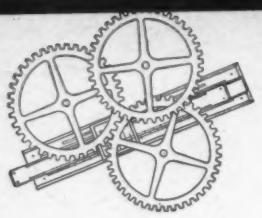
A full range of semi-finished stock shapes will include Nylatron G.S., Nylasint, Fluorosint, Q200.5, K51 Penton, and Nylaflow Tubing. Also to be exhibited are Ferrotron, a ferromagnetic plastics material of advanced formulation for high performance as inductive cores, available in rod, tape, and moulded parts in production quantities; and Corvel, finely divided powders in vinyl, cellulosic, epoxy, nylon and Penton for coating parts of the fluidized bed system.

Precious Metal Devices

The Baker platinum division of *Engelhard Industries Ltd.* will show: a standard range of rivet-type electrical contacts; a new rhodium-plating electrolyte which allows for the deposition of heavy unstressed deposits; a new acid-gold plating electrolyte which is innocuous to most printed circuit adhesives; a new process which allows for the deposition of platinum, palladium, rhodium and ruthenium by chemical displacement; the Atomex immersion gold solution for providing a dense deposit of pure gold by a simple immersion process; a bright silver plating solution to give a mirror-like deposit; a range of precious-metal thermocouples; a variety of special-purpose brazing alloys; the Hersch oxygen meter for the detection and continuous measurement of traces of molecular oxygen in gases; the Deoxo catalytic gas-purification process, which provides for the removal of oxygen or hydrogen from certain other gases; platinum and platinum-alloy fabrications for the chemical and other industries; and several other exhibits.

Knitted Metals and Plastics

Various new developments in the electronic, chemical and engineering fields have been made by *Knit Mesh Ltd.* In electronics, a suit has now been manufactured in silver-copper to act as a microwave protective shield. This suit is very light to wear, and also very flexible. In the chemical and engineering field a demister has been made from knitted polypropylene—this plastics has many advantages because of its corrosion resistance, and it is much lighter than a demister made from steel. The demister has been made in slabs of 12 in. to enable it to be inserted inside existing vessels. Other products include filters, separators and R.F. shields.



Coated Metal Strip

Coated Strip Ltd. will show coils of coated metal strip. The coatings are paint (stove enamel), lacquer (also stoved), embossed p.v.c. (Plastisol), and smooth p.v.c. (organosol), the base metals being steel and aluminium.

In support of the claim that the limit of deformation of pre-coated metal is that imposed by the metal itself, components made from the coated coils will be shown—some loose, and others built into finished assemblies.

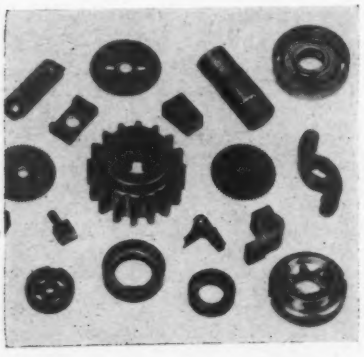
The main feature on the stand will be a retractable aluminium awning made from sections rolled by Metal Mouldings Ltd., using aluminium strip painted on both sides by Coated Strip Ltd. This awning is now readily available in this country.

The potential of Plastisol-coated steel will be demonstrated by beading on lightweight suitcases.

The deep drawing properties of pre-painted steel strip will be shown by a hood for a miniature carpet-sweeper. A complete sweeper will also be on view, as well as a miniature washing machine with sides, back and base made from pre-painted steel.

Metal Sinterings

Some of the components produced by *Sintered Metal Components (Chard) Ltd.* are shown in the accompanying photograph. The firm's products are used in many fields of engineering, the largest single consumer being the automobile industry.

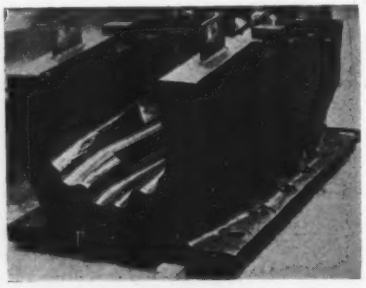


The company produce small engineering components of simple or complex design from metal powder, by a process of compacting the powder to the desired shape and subsequently heat-treating to induce strength and ductility by the technique known as sintering. This is usually followed by a cold forming process (known as re-pressing or coining) to obtain very close dimensional accuracy and/or increased strength. Components are produced having controlled porosity and self-lubricating features.

Steel Castings

Thirty-five exhibits are to be shown on the stand of the *British Steel Founders Association;* they have been selected as notable examples of castings either because they have replaced other materials, because they illustrate significant advances in steel foundry techniques, or because they result from close foundry/client collaboration.

Among recent jobs of particular interest completed by members (and featured at the show) are cable bands (see illustration) for the Tamar Bridge, cast in BS 1456 grade B steel to complex shapes and very close tolerances to conform to



the cables which they are required to hold —they illustrate the value of collaboration from the earliest stages.

An example of great intricacy in steel castings is a series of bogie frames to be made for the Talgo trains in Spain; similar frames have been fabricated in the past, but these have been replaced in this case by steel castings.

Other exhibits of interest will include a ball thrust swivel box for use with colliery suspension gear; a side guide for a rolling mill; an endplate for a mill motor; furnace dampers which have been built up from heat-resisting cast-steel panels (with joints so designed that they prevent the leakage of gases but allow repeated expansion and contraction without loss of shape); an all-cast steel earth-moving bucket; a rotating guide vane for a gas turbine compressor; N.C.B. mine car wheels; heavy-duty lathe chucks; an articulated vehicle hitching plate; coal cutting augers; and valve bodies.

Stock of Steels

Macready's Metal Co. Ltd., stockholders of bright carbon and alloy steels and hot rolled carbon and alloy steels, offer stocks exceeding 6,000 tons covering all the main British Standard EN specifications; these are available for immediate delivery. In the production field an extensive range of free cutting steels is available for the repetition turned part manufacturer; the brands include Usaspead Super free cutting steel, Usaled leadbearing free cutting steel, and Superled leadbearing free cutting steel. The range is extensive, covering diameters in both fractions and millimetres, and also hexagons in unified as well as BSF/BSW sizes.

The requirements of the tool and gauge making industry are catered for with a wide range of Usaflat bright steel flats, stubs and MMC quality silver steel, Usaspead ground flat stock, Usaspead NSOH and Usaspead HCHC oil-hardening tool steels, Unbrako screws, Usaspead dowel pins, etc. The company is approved for the supply of DGI and ARB released steels and a bonded stock of British Standard specification steels is available.

Sintered Bearings

A range of Oilite self-lubricating bearings and structural parts, produced by the sintering process in a range of alloys to suit particular applications, will be shown on the stand of the *Manganese Bronze & Brass Co. Ltd.* These sinterings are said to feature reduction in cost, release of machining capacity, and resistance to wear.

A selection of high-tensile corrosion- and heat-resisting copper alloys, including aluminium bronzes in the form of extruded and rolled rods, bars, tubes, sections and forgings, rolled plate and sheet, will be seen, together with extruded bars, tubes and sections in BS brasses.

Other Exhibitors

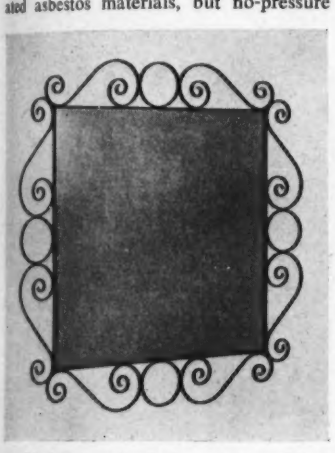
Allspeeds Ltd.
A.P.V.-Paramount Ltd.
Armstrong Cork Co. Ltd.
Armstrong Patents Co. Ltd.
Ashwell & Nesbitt Ltd.
Association of Bronze & Brass Founders
Avdel Ltd.
Bound Brook Bearings Ltd.
British Rolling Mills Ltd.
Carter Gears Ltd.
Chapman & Hall Ltd.
Chesterfield Tube Co. Ltd.
Consolidated Beryllium Ltd.
Dewrance & Co. Ltd.
Engineering Materials and Design
Ferranti Ltd.
Fibreglass Ltd.
Firth-Vickers Stainless Steels Ltd.
Harvey, J. J., & Pressurecast Ltd.
International Meehanite Metal Co. Ltd.
Johnson, Matthew & Co. Ltd.
King Aircraft Corporation Ltd.
Lake & Elliot Ltd.
Langley Alloys Ltd.
Low Moor Alloy Steelworks Ltd.
Low Moor Fine Steels Ltd.
Magnesium Industry Council
Metals & Alloys (B'ham) Ltd.
Midland Silicones Ltd.
Mond Nickel Co. Ltd.
Morgan Crucible Co. Ltd.
Murcott, J. V., & Sons Ltd.
Nadella Needle Bearing Co.
National Steel Foundry (1914) Ltd.
Nylonic Engineering Co. Ltd.
O'Neill & Co.
Plastic Engineers Ltd.
Plessey Co. Ltd.
Precious Metal Depositors Ltd.
Rigby, John, & Sons Ltd.
Russell, S., & Sons Ltd.
Simmonds Aerocessories Ltd.
Small & Parks Ltd.
Smith, John A., Ltd.
Telcon Metals Ltd.
Thermo-Plastics Ltd.
Tough Plastics Ltd.
Venesta Plywood Ltd.
Williams, John, of Cardiff Ltd.
Wilmot Breeden Ltd.
Zinc Alloy Die Casters Association

WHAT'S NEW IN MATERIALS

Row Heater Panel

A new type of heater panel has been developed, moulded from Durestos—a resin-impregnated asbestos thermo-setting moulding material. Incorporating an electrical heating element provided by Thomas French and Sons Ltd., these panels are claimed to have excellent physical strength, and to withstand a deal of maltreatment such as might be encountered in the home; they can be dropped without much damage, although repeated "tests" of this kind are not advised.

Durestos is best cured under heat and pressure, in order to take full advantage of the outstanding characteristics of resinated asbestos materials, but no-pressure



moulded flat sections—in many combinations of size and wattage ratings—can be obtained.

To give some indication of the surface temperature of these heaters, a 2 x 2 ft. panel emits 80-90 deg. C. at 500 watts. The panels are said to be particularly suitable for use as bathroom heaters and towel rails. Other applications which are envisaged include domestic heating (illustrated), incubators or brooders, plate warmers, self-service counter heaters, and seed propagation trays. Most of the popular contemporary finishes can be applied, or the panels can be painted or supplied pigmented. Stains or dirt can be washed off without detriment to the panel surface. *Turner Brothers Asbestos Co. Ltd.*, P.O. Box 40, Rochdale.

EMD 8079 for further information

Solder for Aluminium

Tin-A-Lum, a new fluxless solder for aluminium and its alloys, is claimed to have the following properties:

It tins, without rubbing on, all surfaces easily and thoroughly, and forms a complete bond with the materials on which it is applied. Its bonding strength increases by about 30 per cent within 12 hr.

It melts at 180 deg. C., and has a range up to 350 deg. C. for specific requirements. The melting point rises substantially after soldering.

It is extremely malleable, and can be drawn, moulded and machined to any shape and size.

It has no flux built in, and works without any flux on aluminium, duralumin, pewter, magnesium, tin-plate, zinc diecasts, beryllium, cobalt, ceramic, etc. It is said to be capable of lifting the oxide skin of aluminium and penetrating right beneath it.

It can join any two metals, with no danger of electrolytic action.

It conducts electricity and heat well, and can be chromium plated or polished.

Tin-A-Lum is simple to apply with a soldering iron or a light neutral flame. *Industrial Synthetics (Overseas) Ltd., Tin-A-Lum Division*, 64 Marlborough Grove, London, S.E.1.

EMD 8080 for further information

Ni-Si-Cu Alloy

The new Mallory 53 alloy, containing nickel, silicon and copper, is claimed to have mechanical properties at least equal to those of conventional phosphor bronzes and brasses, coupled with a far higher electrical conductivity. The thermal conductivity of the alloy is also said to be high.

Mallory 53 is claimed to be ideal for contact support springs, especially in miniature components, and is supplied as strip in the precipitation-hardened condition. All spring-forming operations can be performed without the need for further heat-treatment.

Typical properties of Mallory 53 are as follows: specific gravity 8·5; Vickers hardness 195-220; tensile strength 40-45 t.s.i.; elongation (2 in.) 12-16 per cent; 0·1 per cent proof stress in tension 30-35 t.s.i.; electrical conductivity, 40-45 per cent I.A.C.S.; thermal conductivity, 0·42 c.g.s. I.A.C.S.; thermal conductivity, 0.42 c.g.s. units. *Johnson, Matthey & Co. Ltd.*, 73-83 Hatton Garden, London, E.C.I.

EMD 8081 for further information

Bearings for Atomic Power Stations

Nuclear engineering developments have introduced new problems in bearing design, requiring materials which can withstand heavy radiation, operate without oil or grease lubrication, and remain unaffected by immersion in "pond" water. A new addition to the Orkot range of resin-bonded fabrics has been introduced for this application. Known as Orkot Grade TL, it is claimed to be tough and hard wearing, and to have a low coefficient of friction with aqueous lubricants. For dry runnig conditions, it is available impregnated with graphite or MoS_2.

Grade TL is dimensionally stable in the presence of water, and has a high resistance to radiation damage, as follows:

Dosage (*Megarads*)	*Change in edgwise compressive strength* (%)
100	+45
300	+22
1,000	−17

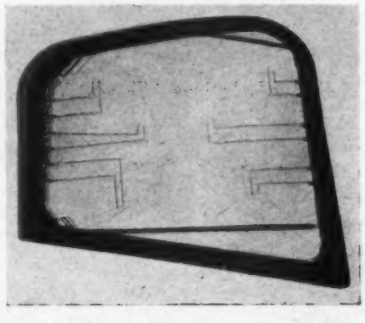
Other mechanical properties of interest are: compressive strength (flatwise) 49,000 p.s.i.; compressive strength (edgewise) 15,000 p.s.i.; impact strength 20 ft./lb./in.; flexural strength 10,500 p.s.i.; flexural modulus $0{\cdot}5 \times 10^6$ p.s.i. *The United Steel Companies Ltd.*, The Mount, Broomhill, Sheffield 10.

EMD 8082 for further information

Transparent Electrically-conductive Material

Sierracote 3, an electrically-conductive material which can be used in the form of a thin transparent coating as the heating element for electrically heated windscreens, cockpit canopies, etc., is now available in this country on licence from the Sierracin Corp. of the U.S.A. When used for the removal or prevention of ice or condensation on cockpit transparencies, it is applied to form one of the inner layers in a laminated construction of glass or plastics material. This ensures complete insulation and protection of the heating element. Special high-vacuum techniques are employed for the deposition process, but since only moderate temperatures are involved, the Sierracote 3 may readily be applied to glass or any of the conventional plastics in use today.

It is said to be possible to apply Sierracote 3 coatings having surface resistances from near zero ohms to infinity. For heating purposes a figure is chosen which is usually within the range 6 to 40 ohms. Coatings with surface resistances within this range have been found to exhibit the best combination of electrical characteristics, physical durability and light transmission. Electrical supplies are fed to the coating via busbars which consist of printed-on (i.e. silk-screened) silver strips in contact with the coating. Flat braided-wire conductors leading from each terminal are laid along the full lengths of the busbars. Normally, busbars form continu-



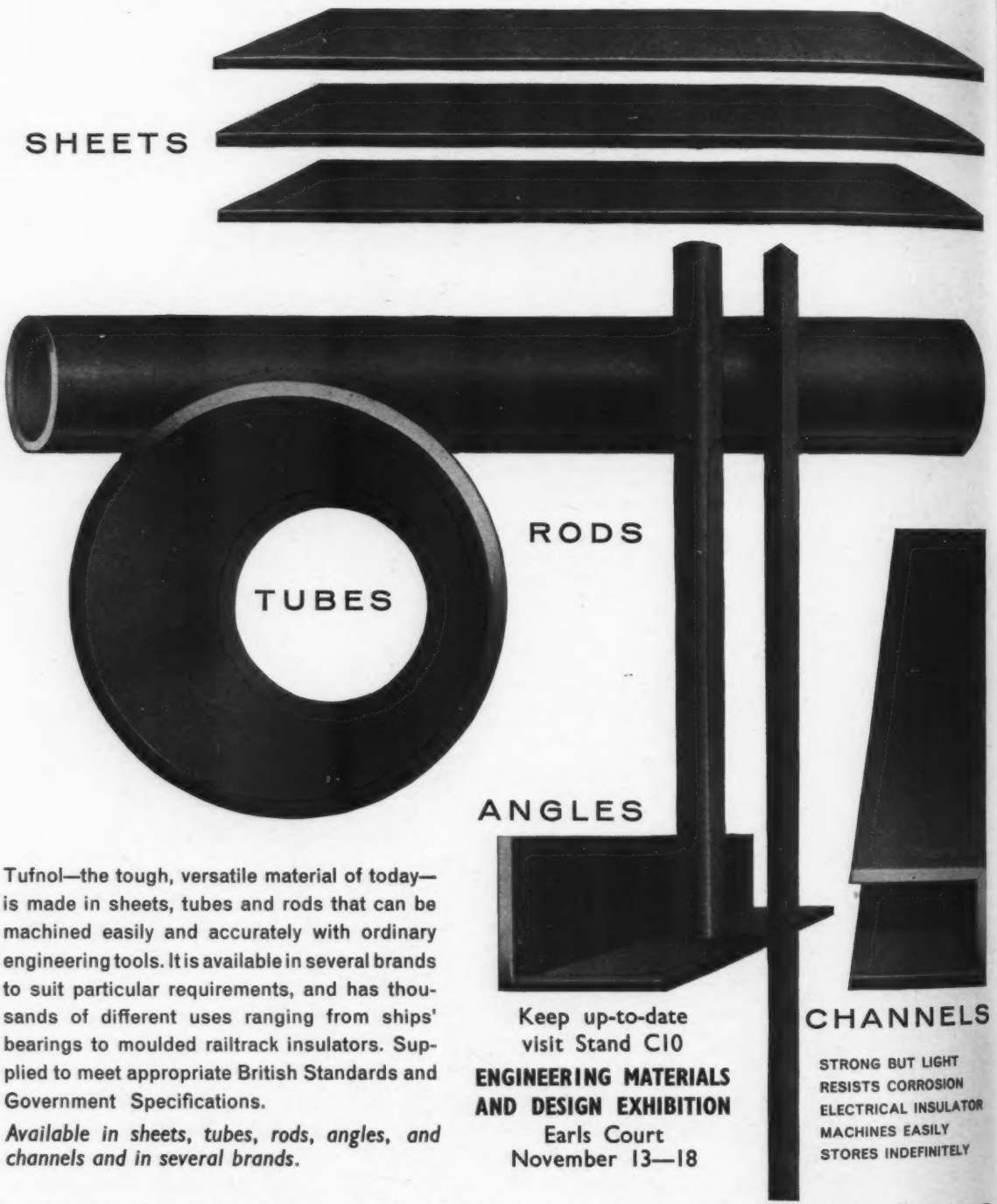
ous strips along opposite edges of the heated panel. Plastics panels may be treated with Sierracote 3 and laminated in the flat state, and then formed to final contour (including a degree of compound curvature) and trimmed afterwards without damaging the coating.

An additional important physical property of Sierracote 3 is its capacity to reflect infra-red light. The majority of applications for it are at present in the aircraft industry, where it is used for de-icing, de-misting and heat reflection. *D. Napier & Son Ltd.*, Luton Airport, Beds.

EMD 8083 for further information

EMD 7964 for further information

TUFNOL



Tufnol—the tough, versatile material of today—is made in sheets, tubes and rods that can be machined easily and accurately with ordinary engineering tools. It is available in several brands to suit particular requirements, and has thousands of different uses ranging from ships' bearings to moulded railtrack insulators. Supplied to meet appropriate British Standards and Government Specifications.

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RESISTS CORROSION
ELECTRICAL INSULATOR
MACHINES EASILY
STORES INDEFINITELY

TUFNOL LIMITED · PERRY BARR · BIRMINGHAM 22B

WHAT'S NEW IN COMPONENTS

Small Air Cylinder

The cylinder shown in the accompanying illustration is of ¼-in. bore, and is double acting. Three standard lengths of

stroke, from ½ to 1½ in., are available. The unit is arranged for rear manifold mounting, and is therefore suitable for mounting in confined spaces where there is no room for pipework to ports. The body is of brass, and the rod of stainless steel, with synthetic rubber distributor type U seals on the pistons, and a similar rod seal in the body. *Air Automation*, 26 Sharrocks Street, Wolverhampton, Staffs.

EMD 8084 for further information

Oil-free Geared Motor Unit

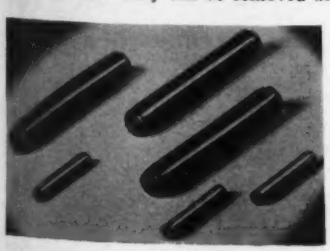
The Gamax II is a compact single-stage epicyclic reduction train built into the end shield of an electric motor, and covers output speeds from 141 to 820 r.p.m. and output torques from 49 to 212 lb. in. The use of Durangus non-metallic gear material for the pinions and bearings, which are sealed for life, is claimed to eliminate the necessity of oil lubrication, a particular advantage in the food, tobacco, dairy and textile industries.

The units are available from stock with totally enclosed fan-cooled motors to BS 170:1939, or suitable for 400-440 volt 3-phase 50 c/s supply. Other motors are available on request. The unit can be foot- or flange-mounted in vertical, inclined or horizontal positions, and self-adjusting planet pinions ensure balanced load distribution. *George Angus & Co. Ltd.*, Angus House, Westgate Road, Newcastle upon Tyne.

EMD 8085 for further information

New Range of Spring Pins

The Spirol range of spring pins, with chamfered lead in, is specially designed for speedy assemblies. These pins absorb shock and vibration, provide uniform flexing and compression, and allow wide hole tolerances. They can be removed as easily as they are inserted, without damaging holes, and can be re-used. The size range is $\frac{5}{32}$ to ¾ in. dia., ½ to 4 in. long. *Lewis Spring Co. Ltd.*, Redditch, Worcs.



EMD 8086 for further information

Charcoal Filters

These filters have been developed primarily for use with the Spembly range of pressure-ventilated protective clothing, where a clean, oil-free air supply is essential. In this connection they are fitted to the Spembly air supply panels, which also incorporate a relief valve, dirt separator and pressure regulator.

The filters consist of an alloy casting containing a cartridge of activated charcoal backed on each side with a resin wool particle filter. The charcoal removes the oil from the air stream by absorption, the cartridge thus needing to be changed at intervals depending upon operating conditions.

To facilitate easy changing of the cartridge, the inlet and outlet points are fitted to the filter body at the side and bottom respectively. This obviates the necessity of breaking air line connections. The lid of the filter body is also alloy, and is secured by three wing nuts and sealed by means of an O ring. The life of the cartridge depends entirely on the density of the vapour and the flow rate, but they have an absorbative capacity of at least 35% by volume.

The filters are made in one size only at present, and can deal with air flows of up to at least 35 c.f.m. For greater flows duplicate filters can be used together with isolating taps to facilitate "on flow" cartridge changes. Special filter panels and associated clean air equipment can be provided as required. *Spembly Ltd.*, New Road Avenue, Chatham, Kent.

EMD 8087 for further information

Patterned Nameplates

A new range of patterns for industrial name plates, escutcheon panels, instrument facias and dials is announced. Any combination of 300 background patterns can now be incorporated at no extra cost to the customer, and the plates can be supplied deeply etched and/or anodized in black or any combination from a wide range of intense and permanent dyes. The degree of etching available enables plates with three dimensional effects to be obtained, while the colours are claimed to remain absolutely true to shade, irrespective of production quantity. The variety of colour and background combinations now possible virtually gives manufacturers' designers and stylists complete freedom of nameplate patterns. *Millett Levens Ltd.*, Stirling Corner, Borehamwood, Herts.

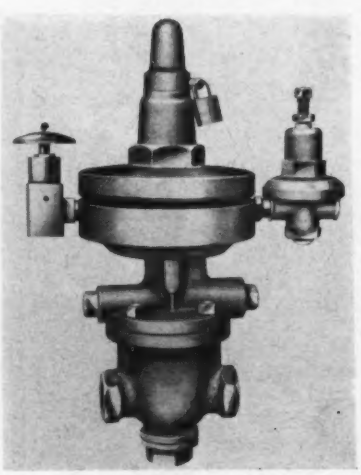
EMD 8088 for further information

Quick-filling Steam Attachment

The time taken to fill a vessel with steam to a required pressure is said to be reduced by as much as 75 per cent by using a new quick-filling attachment. This time reduction is obviously important in, say, hospital sterilisation, but it can also mean increased production in various industrial processes, as the time taken for an operating cycle can be reduced.

The new patented quick-filling attachment, which is designed for incorporation in a Bailey reducing valve, obviates the delay inherent in the use of all conventional reducing valves, by which the rate of pressure build-up decreases as the required setting is approached. The attachment allows full steam flow through the valve to be maintained until the pressure is within 2 p.s.i. of the set pressure. At this stage, a special diaphragm control valve lifts to admit steam to the underside of the diaphragm of the reducing valve, which then operates as usual. The attachment can be supplied as a conversion unit for existing Bailey Class "G3" reducing valves, or already incorporated in new Class "G3" or Class "A" valves *Sir W. H. Bailey & Co. Ltd.*, Albion Works, Patricroft, Manchester.

EMD 8089 for further information



EMD 7965 for further information

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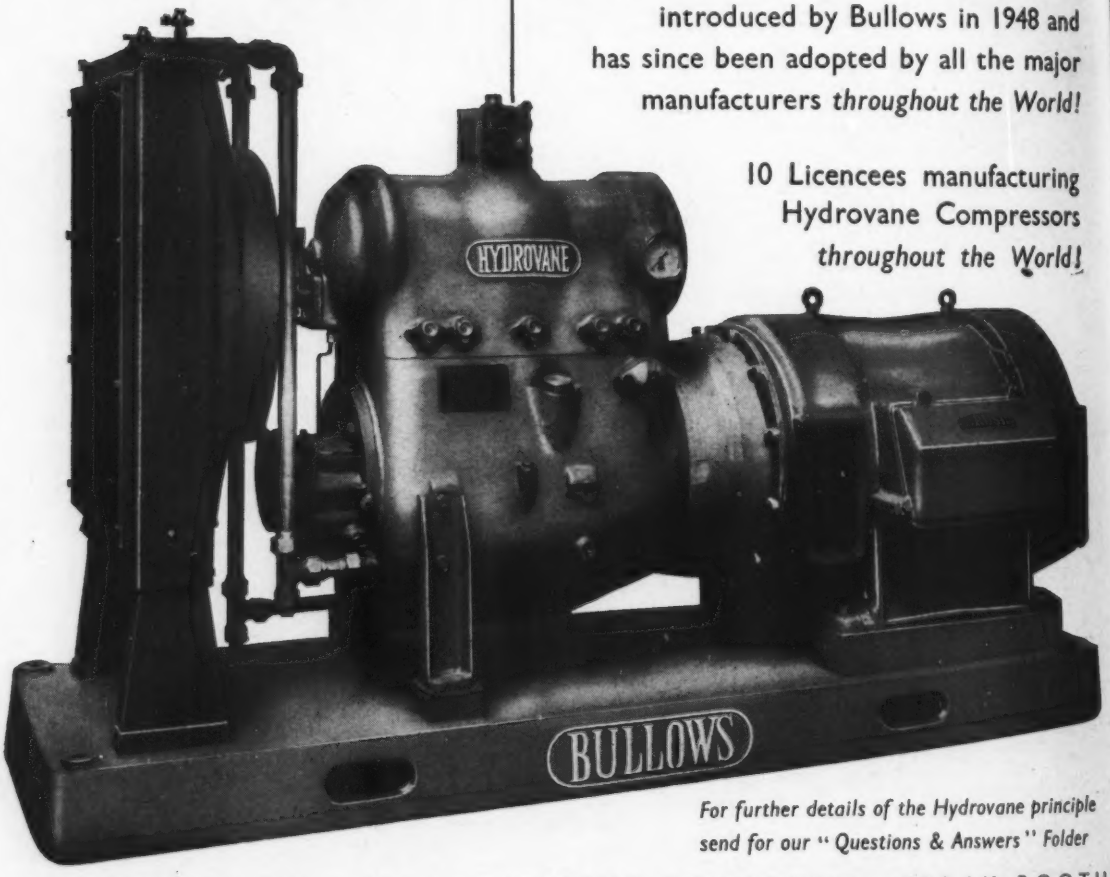
10 Licencees manufacturing Hydrovane Compressors *throughout the World!*



For further details of the Hydrovane principle send for our "Questions & Answers" Folder

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WHAT'S NEW IN COMPONENTS

Wander Button Switch

A new Wander Button switch comprises a miniature push-button switch located in a neoprene rubber case designed for comfortable hand operation. The switch is enclosed in a rubber moulding to minimise the risk of accidental operation.

The switch (reference C.5162.Y.) incorporates a positive detent action, and is available with a wide variety of two pole make-and-break contact arrangements. It is designed to operate in temperatures ranging from −65 to +70 deg. C. at altitudes up to 60,000 ft. switching 5 amps. resistive at 28 volts d.c.

Terminations are provided in the form of trailing leads enclosed in Superflexit

conduit, the length of which may be varied to suit individual applications. *Dowty Electrics Ltd.*, Tewkesbury, Gloucestershire.

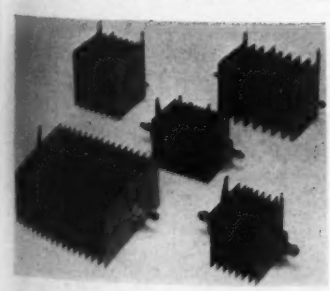
EMD 8090 for further information

Crystal Aligned Rectifiers

Westinghouse H series crystal aligned rectifiers incorporate aluminium-base selenium elements manufactured by an automatic and closely controlled vacuum deposition process. These new process elements have a crystal aligned selenium layer and an improved back contact giving characteristics which result in a greatly improved service life expectancy, together with higher current densities than were previously permissible.

While developing the thermal design of the units particular attention has also been paid to eliminate the tendency for elements to twist on their spindles where acceleration or vibrations are present. Incorporated in the new mechanical design are features claimed to eliminate this possibility. *Westinghouse Brake and Signal Co. Ltd.*, King's Cross, London, N.1.

EMD 8091 for further information



Cable Identification Sleeves

Helagrip is a sleeve made from high-quality flexible p.v.c. and designed for fitting without the aid of tools. It is sup-

plied in sizes covering the cable diameters $\frac{1}{8}$ to $\frac{7}{16}$ in. The sleeves are interlocking and remain in position even when the cables are turned through 90°. The interlocking design ensures alignment of characters, and facilitates fitting

Helagrip is supplied in a standard colour of white with black printing. Codings A to Z and 0 to 9 are available from stock. It is supplied in strip form, partially cut to ensure correct positioning of the marker, and has C.E.G.B. Type Approval No. 43. *Hellermann Ltd.*, Gatwick Road, Crawley, Sussex.

EMD 8092 for further information

Coaxial Ratio Transformers

A range of coaxial ratio transformers —the CRT-1, 2, 3 and 4—with indicated ratio accuracies of from 0·01 to 0·001% between 50 and 10,000 c/s, is now available. Common features of all four models are high input impedance, a terminal linearity of 0·001%, continuous resolution by means of in-line concentric dials, very low phase shift and an input inductance of 150 henrys. The units weigh approximately 7 lb. each.

Models CRT-1 and CRT-2 are designed specifically for restricted panel space, five units being easily mountable on a 3½ × 19 in. panel. The CRT-1 offers six-place digital readout; the CRT-2 is identical, except for a single-turn potentiometer.

The CRT-3 and CRT-4 are subminiature types designed particularly for applications involving small panel areas with minimum depth and requiring units to meet military specifications. In spite of their small size, both the CRT-3 and 4 have an accuracy of 0·001%, the CRT-3 giving five-place resolution and the CRT-4 six-place resolution. *Wayne Kerr Laboratories Ltd.*, 44 Coombe Road, New Malden, Surrey.

EMD 8093 for further information

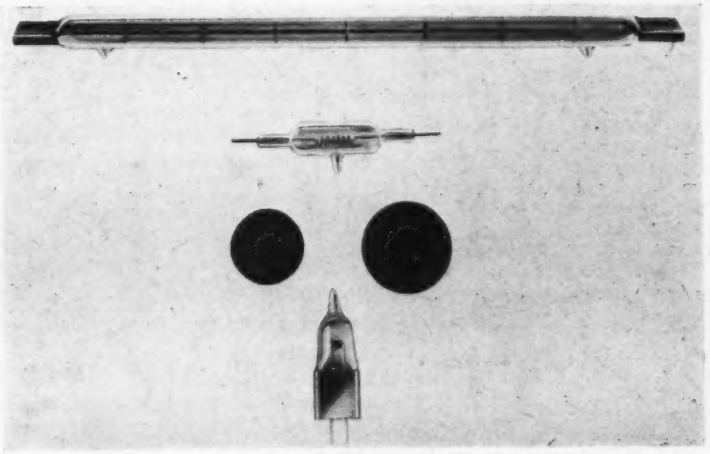
High-power Miniature Lamps

A new miniature iodine-filled filament lamp is claimed to be a major advance in incandescent electric lighting. The first application of the new principle is for floodlighting, where it is emphasised that the specially designed fittings of the iodine lamp, and its extremely small size and robust construction in quartz, will enable it to be integrated into ground installations with great advantages, and also enable it to withstand extremes of weather and be more resistant to shock and vibration hazards.

The second form of iodine lamp in development is a tubular filament in 500, 1,000 and 1,500 wattages for floodlighting and for industrial and arena lighting. The 1,500 watt lamp is only 9 in. long and ⅛ in. dia., compared with the standard equivalent of 14 in. long and 6½ in. dia. Fittings could be correspondingly smaller and lighter, but it is emphasised that this form can be readily adapted to present standard fittings. Its small size and light weight enable it to provide more efficient optical control and concentration on an object without dazzle.

The principle of the new lamp is that the addition of a trace of iodine vapour to the argon filling sets up a regenerative cyclic reaction. This continuously removes deposits of evaporated tungsten from the bulb wall and returns them to the filament. The blackening which occurs in small lamps of normal construction is thus avoided, and the light output of the lamp is said to remain almost constant throughout its life. *Osram Lamp Division, General Electric Co. Ltd.*, East Lane, North Wembley, Middlesex.

EMD 8094 for further information



When did *you* last see a Dutch interior? Never mind! The point is that there's an art to protecting the interiors of tanks. And Ensecote has it. *Any* size of tank. *Any* sort of liquid practically. Ensecote protective linings are easily cleaned and sterilized; completely odourless, tasteless, and economical to install (larger vessels can be lined on the spot). Ensecote protective linings add years to a tank's life. *And no one else but Newton Chambers can supply them.*

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WHAT'S NEW IN THE OFFICE

Drawing-storage Units

A new range of Ranplan drawing-storage steel cabinets is now available. All units are standardised with fourteen 1-in. deep trays and a height of 22 in., with variable width and back-to-front dimensions. The trays can be supplied subdivided into compartments providing two or four divisions to accommodate smaller size drawings. This method avoids the misplacement of small drawings interleaved with larger sizes.

Made from zinc-coated steel sheet, the cabinets are stove-enamel finished in dual-tone light and dark battleship grey. Strong in construction, Ranplan units are designed

for stacking where space economy is vital. A simple lug, fixed on the back of all cabinets, holds stacked units firmly in position. *J. H. Randall & Son Ltd.*, Paddington Green Works, London, W.2.

EMD 8095 for further information

Instant Lettering

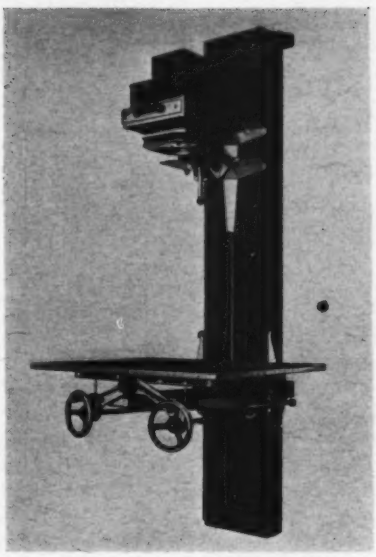
Letraset "Instant Lettering" provides a means whereby letters can be simply and rapidly transferred from a plastics sheet, on which they are mounted, to the drawing, tracing or art work on which they are required. It is not necessary to cut around the letter. Each letter is a self-adhesive transfer, secured to a thin transparent plastics film. To transfer the letter to the work it is only necessary to position the letter over the right spot and then, with the round end of a fountain pen, or the point of a ball pen, to burnish the upper side of the letter through the plastics sheet. This action causes the contact adhesive on the letter to adhere to the work, and at the same time breaks the adhesive bond between the letter and the plastics sheet. The whole procedure only takes a matter of seconds. Where letters are to be exposed to the weather, a varnish finish may be applied. *Letraset Ltd.*, Artist House, Plough Place, Holborn, London, E.C.4.

EMD 8096 for further information

Enlarger with Many Applications

The Kamm enlarger, which is suitable for enlarging drawings, maps, artwork, etc., is claimed to obviate maintenance almost entirely. Construction consists of a self-supporting welded box form section, with adjustable wall-mounting brackets. The moving parts are ball-bearing mounted, and are operated through heavy-duty cable by two control handles in front of the machine. The enlarger head supports a 12-in. cold cathode lighting unit and negative holder to take negatives up to 10 × 8 in. A condenser head can be supplied instead if required. There is a micro-switch to prevent light spill when changing negatives.

Maximum enlargement is ensured by the lens and mount, which have been designed as an enlarger head to give



minimum distance between negative and lens. The quick-action release lens mount enables movement around the optical axis. A swing filter is provided. The tilting table measures 40 × 30 in., and is supported by a grid to maintain flatness. Locking for tilt is brought about by a knob immediately below the table surface. The control unit permits a wide angular position of control handles, and there is ample knee room for the operator. A clutch unit, adjustable to any requirement of sensitivity, also locks the control wheels. The many extra accessories available include a recessed lens holder and a 5 × 4 in. film holder; a 2¼ × 2¼ in. film holder; and a plate holder for converting to copy camera. *Colyer & Southey Ltd.*, 17-18 Tooks Court, Cursitor Street, London, E.C.4.

EMD 8097 for further information

New Publications and Technical Literature

Magnesium Elektron Ltd.: 23-page brochure on the protection and surface treatment of magnesium alloys, and a separate chart showing mechanical properties and chemical compositions. Clifton Junction, Swinton, Manchester.

EMD 8098 for further information

Precision Rubbers Ltd.: *Skydrol Resistant Rubbers* (Issue 2) deals with the new Prescothene compounds, which have been developed to give good wear, low compression set and temperature resistance up to 150 deg. C. Bagworth, Leicester.

EMD 8099 for further information

Stillite Products Ltd.: Comprehensive manual giving data on the thermal insulation of pipework, intended as a guide for those who wish to estimate heat losses and temperature gradients in insulated systems. Print Supervision Ltd., 8 Buckingham Street, London, W.C.2.

EMD 8100 for further information

Brown, Lenox & Co. Ltd.: 26-page illustrated brochure which, apart from describing the firm's product, also constitutes a very comprehensive guide to the selection of steel castings. Pontypridd, Glamorgan.

EMD 8101 for further information

International Engineering Concessionnaires Ltd.: well-illustrated 36-page brochure describing the new Automat engineering construction sets. 39 Parliament Street, Westminster, London, S.W.1.

EMD 8102 for further information

Solartron Electronic Group Ltd.: Leaflet of general technical data on tangential fans. Accessories Division, Victoria Road, Farnborough, Hants.

EMD 8103 for further information

United Steel Companies Ltd.: Well-produced 36-page brochure describing the Distington iron foundry at Workington. The Mount, Broomhill, Sheffield 10.

EMD 8104 for further information

Magnesium Elektron Ltd.: 91-page revised edition of the pocket-size *Magnesium Data Book*, a compendium of useful facts about magnesium with special reference to Elektron alloys. P.O. Box 6, reference to Elektron alloys, Clifton Junction, Swinton, Manchester.

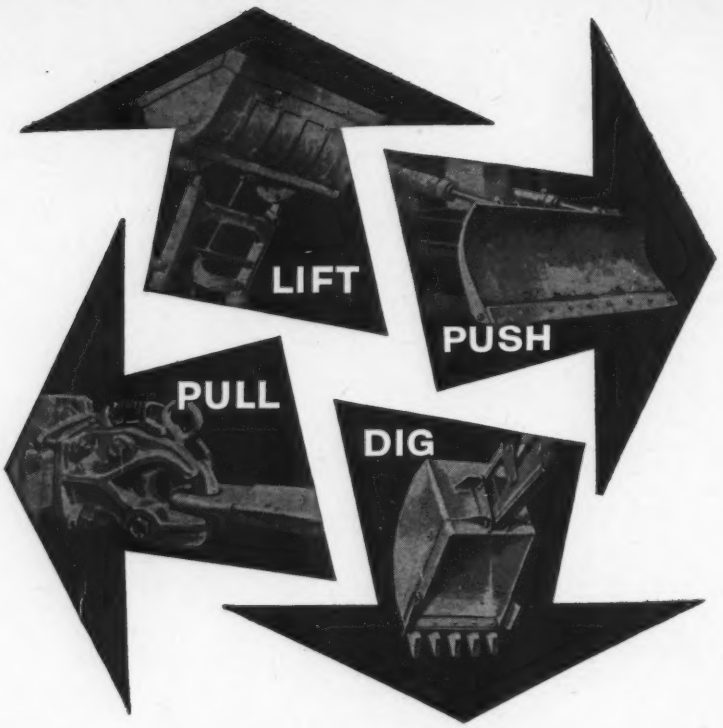
EMD 8105 for further information

Extrudex Ltd.: 36-page brochure detailing and illustrating the firm's range of p.v.c. tubes, fittings and valves, and describing methods of jointing. Highams Park, London, E.4.

EMD 8106 for further information

Albright & Wilson Ltd.: *Survey of a Chemical Group*, a well-produced 72-page brochure giving a comprehensive account of the character and activities of the Albright & Wilson Group of chemical companies. 1 Knightsbridge Green, London, S.W.1.

EMD 8107 for further information



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Torque lbs/ft (nett)	162 @ 1200	92 @ 1200
GEAR RATIOS (6 speed constant mesh)		
1st Gear	6.62 : 1	30.5 : 1
2nd Gear	4.70 : 1	17.0 : 1
3rd Gear	3.68 : 1	10.28 : 1
4th Gear	2.61 : 1	7.55 : 1
5th Gear	1.87 : 1	5.73 : 1
6th Gear	1.04 : 1	2.53 : 1
Low Rev	4.90 : 1	6.30 : 1
High Rev	2.73 : 1	18.70 : 1
REAR AXLE RATIOS		
Crownwheel and Pinion	3.5 : 1	6.66 : 1
Spur Gear Reduction	5.308 : 1	—
Overall Reduction	18.58 : 1	—

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WISE BUYERS INSIST ON

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News of Industry

Solid State Computer

Remington Rand recently demonstrated the Univac high-speed computer. Extensive use of tiny magnetic core amplifiers enables the Univac equipment to be installed in a much smaller area than is normally required for a computer able to perform the same functions. Its remarkable speed and large storage capacity enables this unit to eliminate considerable pre-sorting and collating, since it combines, in a single run, calculations, reproduction, gang punching data, collating and tabulating.

Plastics Street-Lighting Column

A new street-lighting column made of glass fibre bonded with Beetle polyester resins has just been developed by *A. C. Ford Ltd.*, of Dudley. The complete column is impervious to any form of corrosion, and will withstand considerable vehicle impact. In the case of a crash, damage to the vehicle and risk of injury to driver and passengers is also reduced. The surface finish is smooth and polished, and since colour is inherent in the manufacture it is fast throughout, and the column requires little maintenance. The overall weight of the unit is only 45 lb.—it is thus easily transport and erected.

The column comprises a 16-ft. single taper tube with a 9-in. dia. base and a 2½-in. dia. top. Two feet of this length is for sinking in the ground. Cable access is by a conventional slot in the base, and the lamp control gear is housed behind a door in the column. Bracket arms for top or side entry lanterns can be supplied in steel tubing covered with plastics in a matching colour.

Vertical Multi-stage Pump

The range of standard horizontal single-stage process pumps made by the *David Brown Foundries Division*, under licence from The Bingham Co., Oregon, U.S.A., has now been extended to include special multi-stage designs.

A combination of design features and application duties presented arduous requirements when it came to the manufacture of multi-stage designs of the vertical type. Basically, this type of unit comprises a vertically-split inner casing (illustrated) contained in a stainless steel barrel; rotary elements are easily accessible. All the materials chosen are those with characteristics enabling them to withstand the abnormal working conditions to which they will be subjected. The radial balance, which is an outstanding feature of the David Brown Bingham double volute design, is fully retained. Moreover, discharge pressure completely surrounds the inner case, and inter-stage leakage is thus avoided. Particularly intricate problems were encountered during pattern-making and moulding in the production of these multistage pumps.

Spin Welding

Du Pont engineers, after completing a series of tests on prototype welds, have concluded that spin welding is a practical method of permanently joining cylindrical mating parts fabricated from Teflon f.e.p.-fluorocarbon resin.

In the spin welding technique widely used for bonding many other thermoplastics resins, high-speed rotation of one part against the mating face of another generates friction heat. When the temperature is sufficient to develop an interfacial film of molten plastics, motion is stopped and the film solidifies to a solid weld.

Despite the high melting point and low coefficient of friction of Teflon, completed welds exhibit tensile strengths approximately 60% of those obtained from wall sections of the parts being joined. The time required for each spin weld, using a standard shop drill press, was only a few seconds.

Continuous Belt Filter

The basic principle of continuously cleaning the filter cloth so that a fresh medium is always available has long been recognised as being imperative in the achievement of the most efficient filtration. However, many problems in the practical application of the principle remained unsolved until the development of the belt filter. Such a unit is now commercially available, from Eimco (Great Britain) Ltd., after a five-year research and development programme of laboratory, pilot plant and full-scale testing.

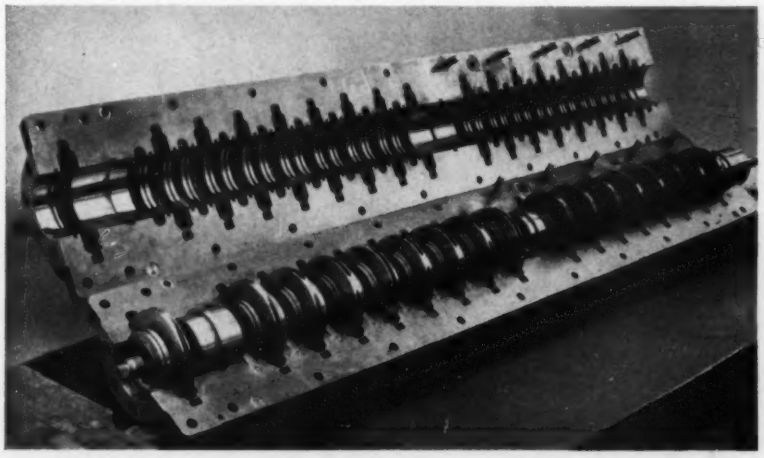
With the Eimco belt principle of an endless filter cloth which is constantly removed from the filter surface for cake discharge and cloth cleaning, distinct advantages, such as the elimination of cloth blinding, cloth changing in half-an-hour or less (instead of several hours), and minimum cake moisture can be realised. Successful installations are now operating on such varied process applications as cobalt, uranium, chromium, beet and cane sugar, sewage and industrial wastes, corn, apples and other food, paper, chemicals and fertilisers.

The development, in the field of sedimentation, of high torque machines to remove continuously the settled solids to the discharge point has been of paramount importance. This has permitted the processing of a wider range of solids while producing higher solids concentrations in the underflows. Not only are processing costs reduced, but greater recovery of valuable materials, either in liquid or solid state, is achieved.

New Advance in Numerical Control

Engineers are now able to describe a three-dimensional shape in terms of its surfaces, leaving a computer to generate automatically the correct path to be followed by machine tools which make the part. In a recent demonstration by *I.B.M. United Kingdom Ltd.*, a complex gearbox cover was described in 180 one-line statements in Autopromt, the new language, and this information was processed by an IBM 7090 computer to generate more than 8,000 tool-path instructions. The computer's instructions, recorded on perforated paper tape for use by the machine tool, enabled the milling job to be completed in about one-fourth of the machine time previously required to mill the same part by conventional methods.

The concise language of Autopromt enables the programmer, working from an engineering drawing, to describe the surfaces to be milled in familiar machine-shop terminology. The description of the part, handwritten on a coding sheet, is then punched into cards fed into a computer which automatically generates the tool travel instructions for each surface to be machined. Tool paths generated are recorded by the computer on magnetic tape. If required this may be converted to perforated tape for input to a machine director, to control the machine tool.



Pressure Vessel Development

One of the major manufacturing achievements of *John Thompson (Wolverhampton) Ltd.* in the nuclear field has been the manufacture of the stainless steel reactor vessel for the Dounreay nuclear power station. This vessel is believed to be the most complicated stainless steel pressure vessel ever to be produced. It involved new constructional methods, special apparatus and newly developed welding and X-ray techniques.

Another achievement by the group has been the development, by *John Thompson (Dudley) Ltd.*, of welded pressure drums for the transportation of liquefied refrigerant gases and aerosol propellants.

Copper Electroforms

Decca Radar Ltd. have established the largest copper electro-forming production plant in Europe. The electro-forming technique known as the Deccaform process is based on the electro-deposition of copper using both low-temperature soluble and stainless steel formers; parts of high dimensional accuracy having excellent electrical properties are produced. A very important feature of the process is that any metals on which copper can satisfactorily be deposited may be used as inserts over which the copper is grown. These inserts then become an integral part of the finished article.

Some of the many applications for electro-formed components include various types of high-precision waveguide tubing; heat-exchanger components; toroids and special tubing; components for use with maser experiments; specialised microwave applications and component heat sinks; as part of a caesium clock; special copper vessels for use as liquid containers; combined electric and hydraulic or gas terminations for heavy electrical machinery; and parabolic, conical and other mirrors of complex form.

New Ford Cars

The *Anglia* is now available as an estate car with the same mechanical features as the saloon. The one-piece tailgate is counterbalanced by torsion bars and can be raised by finger tip to above the horizontal, where it is self-supporting. When the rear seat is folded forward a completely flat 54-in. long floor becomes available, and 35·4 cu. ft. of space of which 20 cu. ft. is below window level.

The *Consul Capri*, a 1,340-cc. "personal" saloon, combines in one model the prestige of the specialist vehicle, the élan of the sports car, and an all-round economy. The Capri shares the basic mechanical specification of the Classic, having a high-efficiency 1,340-cc. o.h.v. "oversquare" engine which develops 54 b.h.p. at 4,900 r.p.m., a four-speed floor or steering-column-controlled gearbox and a hypoid rear-axle. Stability and roadholding with high degree of comfort are provided by the Ford front suspension system, with special rear springs which cater for the Capri's individual load characteristics. Its aerodynamic shape results in an enhanced performance and a top speed exceeding 80 m.p.h. (laden). Front-wheel disc brakes are standard fittings.

Yes, here in the hydraulics section we're always under pressure.

Meetings

A conference on International Developments in Heat Transfer is to be held in London from January 8 to 12, 1962, arranged jointly by the *Institution of Mechanical Engineers*, the *American Society of Mechanical Engineers* and the *Institution of Chemical Engineers*.

The winter meeting of the Powder Metallurgy Joint Group of the *Iron and Steel Institute* and the *Institute of Metals* will be held at Church House, London, S.W.1 on December 7 and 8, 1961. The main discussion will be a symposium on Sintered High Temperature Compounds.

The Institute of British Photographers has announced that a special three-day conference for industrial and cine photographers will be held at the Central Hall, London, from December 5 to 7, 1961.

The Measurement and Control Section of *The Institution of Electrical Engineers* is arranging a symposium on Nuclear Electronics, on November 30 and December 1, 1961, at their headquarters. The symposium will consist of three sessions: "Radiation Detectors", "Electronic Circuits and Techniques", and "Radiation Monitors and Instruments".

A course of six evening lectures will be held at the *Borough Polytechnic* in February and March 1962, under the general title Factors Affecting Engineering Design. This course is intended for practising and potential design engineers; the lectures will be given by men prominent in engineering design.

New Films

The latest sound and colour film by Brook Motors Ltd. is called *All in a Day's Work*, and runs for 17 min. It deals with great numbers of both large and small electric motors that are produced daily, and shows many interesting manufacturing sequences. Applications for free loan should be addressed to Publicity Department.

The following new 16-mm. films are now available on free loan from the Central Film Library: *An Introduction to Ion Exchange*, 26 min. in colour; *The Clean Heat Treatment of Metals*, 33 min. in colour; and *A Question of Aptitude*, a 12 min. German film with English commentary on aptitude tests for the selection of industrial apprentices (there is a hire charge of 5s. per day for this film); *Zinc Controls Corrosion*, 39 min. in colour; and *Die Casting — How Else Would You Make it?*, 35 min. in colour. The new 1961-2 edition of the *Films for Industry* catalogue is now available at 3s. from the Central Office of Information.

A 16-mm. 20-min. colour film entitled *The Production of Hydraulic Cylinder Tubes*, made for Tubes Ltd., describes the various stages in making seamless steel tubes.